

16/1/61.

EXD

HÖFCHEN-BRIEFE

BAYER PFLANZENSCHUTZ-NACHRICHTEN

English edition

No. 3, 1960

PUBLISHED BY THE BAYER CROP PROTECTION DEPARTMENT
LEVERKUSEN AND HÖFCHEN

CONTENTS

	Page
1. G. Unterstenhöfer: On the present level of resistance to insecticides and acaricides	141
2. W. Kolbe: On the joint control of mangold fly and aphid species on beets, with LEBAYCID®	150
3. Karlheinz Kütke: Experience on the use of FOLIDOL® Oil for treating pome fruit, especially against winter moth (<i>Cheimatobia brumata</i> L.)	177
4. K. Krämer: Tests on the Control of Apple Fruit Moth (<i>Argyresthia conjugella</i> Zell.)**	185

Reprints permitted with reference to origin

BAYER LEVERKUSEN (GERMANY)

Department for Crop Protection

On the present level of resistance to insecticides and acaricides

(Paper presented at the Austrian Crop Protection Congress, 1960 in Vienna)

by G. Unterstenhöfer, Leverkusen

A biological problem of scientific interest and practical importance, which is today directly associated with the chemical control of insects and mites, is resistance to insecticides and acaricides. To my knowledge this problem has not yet been encountered in Austria, at least not in agriculture, and also in the rest of Europe occurrence of resistance in crop protection attaches only local importance, yet nevertheless it seems most appropriate to present an objective picture of the situation, based on scientific studies and sound field observations.

Resistance to insecticides, in the narrow sense of the term, is understood to mean — and this also applies to resistance to acaricides unless otherwise especially emphasized — the phenomenon that occurs when active materials, having once been successfully used against a certain insect for a long or short period, progressively lose their efficacy until they may finally become unsuitable for control. Therefore, an insect species, originally susceptible, has become resistant or tolerant to an insecticide.

This form of developed resistance to insecticides must be carefully distinguished from the natural resistance of certain insect species to an insecticide, inherent in them from the very outset. These so-called species-specific differences in reaction to poisons, which are reflected in the spectrum of activity characteristic of every active material, and which are to be regarded as unalterable natural constants, admittedly come under the category defined as resistance to insecticides but in the broader sense of the term. In order to preclude any misunderstandings, I would expressly emphasize that our present discussion does not concern this species-specific resistance to insecticides, nor will it be included in our consideration although for reason of its ultimate synonymous action it is probably related in some form to the acquired strain-specific resistance suitably defined as such in contrast to the species-specific resistance. I deliberately coin the term "strain-specific" here following the example of the terminology chosen in mycology for so-called biological specialization because genuine parallels undoubtedly exist between biological and resistant strains.

The acquired or developed resistance or tolerance of insects to insecticides is not a phenomenon recently observed for the first time. On the contrary, it was established already in 1913/14 for San José scale against lime-sulphur mixture, and again in 1916 when California red scale (*Aonidiella aurantii*) was found to be resistant to hydrocyanic acid. But resistance to insecticides did not become an urgent problem until, following wide use of synthetic insecticides, it

was found that some insect species, especially those with a high reproduction potential and a large number of generations, may become resistant relatively quickly. The reports on this trend, at first received with scepticism, were, however, irrefutably confirmed later by the development of dichlorodiphenyl-trichloroethane-resistance both in the house fly (*Musca domestica*) — simultaneously established in several countries — and in various mosquito species and body lice.

Thus, the public health services, both civil and military, at first found themselves faced with weighty problems insofar as the diseases transmitted by insects, such as malaria, yellow fever, encephalitis, dysentery, sleeping sickness and typhus, which had been largely suppressed and in fact almost eradicated in some regions by the use of these products, once more threatened to gain an upper hand. Resistance to insecticides also presented a problem to agriculturists as synthetic organic insecticides were applied on a vastly increasing scale for controlling pests of agricultural crops, and it was discovered that certain pest species are perfectly capable of developing resistance.

In a paper published in 1955 on the physiological basis for insect resistance to insecticides, Metcalf provides a table of hitherto authentic cases of insecticide-resistance, revealing that not only insects but also spider mites are capable of developing resistance to the most varied groups of active materials, both organic and inorganic poisons including chlorinated hydrocarbons, organophosphorus compounds, arsenic, selenium and sulphur compounds. The table also shows that both gases (HCN) as well as stomach (arsenic) and contact poisons are involved, and that even though the most cases are registered in the U.S.A., resistance phenomena exist also in other countries. During the 5 years that have since passed, more cases have occurred. One that deserves special mention here is the resistance of boll weevil (*Anthonomus grandis*) that has developed in Louisiana, the Mississippi Delta and South Arkansas to chlorinated hydrocarbons such as BHC, dieldrin, endrin, heptachlor and toxaphene. Exact studies showed that resistance is increased one-hundredfold as compared with strains of normal susceptibility. In Europe, resistance registered in agricultural crop protection is fortunately only of a regional character, outstanding being the resistance of spider mites to organophosphorus compounds, and more recently also to P-free selective acaricides; mention should be made, too, of the resistance of potato beetle to chlorinated hydrocarbons likewise only observed regionally. Finally, it should be emphasized that the scale of known insecticide-resistance has meanwhile risen, and is still in the process of increasing even more. Chemical pest control is, therefore, apparently faced with the same problems as the breeding of resistant crop varieties. Impressive examples include the breakdown of phytophthora- and canker-resistance of potatoes, and the collapse of smut and rust resistance of wheat. Both chemical pest control and breeding of resistant crop varieties have always to contend with the uncertainty of new strains occurring which ruin the initial successes. It is at first immaterial whether the cause is due to increased aggressiveness of the pathogenic fungus towards the host, as is the case in the breeding of resistant varieties, or due to an increased tolerance of a pest to a poison as in insecticide-resistance. At all events, it is certain, as I shall demonstrate later, that the active principle which brings about the downfall of success, is the same. Nevertheless, it is most striking that, with the exception of a few alleged cases,

resistance to fungicides so far could not, to my knowledge, be established with certainty. But this by no means proves that fungi are not capable of developing resistance. Exacting experiments in this direction would be worthwhile if only because a unilateral biological specialization for the host, such as present in the breakdown of resistance-breeding, is to be regarded as hardly probable. At all events, one may quote, in respect of chemical pest control, the same words of Gäumann, which Braun (1950) cites at the close of his publication on "Resistance-breeding and biological specialization": "The mental attitude of the breeder — in this case, the insect toxicologist — thus corresponds to an undaunted pessimism: he will never reach his goal — for this continues to be further delayed — but rathermore he is content when he remains several years or decades ahead of his parasitic pursuers".

Genuine parallels to insect resistance to insecticides are also known in human medicine, to mention only the resistance of bacteria to antibiotics and sulphonamides. Furthermore, I am sure it would not be deviating from the subject to point out that in 2 years rabbits became immune to myxomatosis. I have raised the courage to mention this perhaps somewhat dubious example because "resistance specialists" have done so, thus wishing to express that organisms with a marked genetic heterogeneity are very probably just as potentially capable of also resisting, in the long run, biological opponents such as viruses, parasites and predators. The plasticity of the world of organisms, drastically brought to view by the above-mentioned examples, gives the pests and their control the dynamic character specific of them. Principally speaking, from the aspect of control techniques, a new pathogen biotype or a new resistant strain is to be compared to a new causal organism or a new pest, for which new control measures must be devised. After all, in this lies the economic importance of insect resistance to insecticides.

In view of this situation, it is comprehensible that close attention is given to the problem of insecticide-resistance. One can hardly keep pace with the great abundance of publications in which the authors describe their intensive efforts to analyze the problem and examine the essential elements. The object of these studies, entailing researches of the development, the heredity, the stability and especially the mechanism of resistance, is to discover new ways of controlling resistant pests or to become acquainted with possibilities of preventing or delaying development of resistance.

Whereas state research institutes and universities devote their attentions to the fundamentals of resistance, one of the main tasks today of the competent and experienced institutes of the chemical industry is to develop new active materials which can be used for controlling species that have meanwhile become resistant to insecticides.

In the following comments, a brief outline will be given of the substantial knowledge gained on resistance to insecticides and acaricides. My reason for referring in essential points to results obtained with house flies (*Musca domestica*) is because especially intensive research has been carried out on this easily handled object, and because so far there is no evidence to refute that the findings accumulated in this work have general validity, beyond the special case, for the elementary fundamentals of resistance to insecticides, in other words that such findings may also be applied to resistance problems of interest

in the crop protection field. At all events, it may be asserted that spider mites basically behave like flies.

Insofar as special knowledge exists, resistance of spider mites will be mentioned to complete the picture for the reason that this group of pests, like the house flies and different mosquito species, has a marked tendency towards development of resistance to widely varying groups of active materials, and because resistance to insecticides, in addition to the resistance of potato beetle, may cause us prime trouble in Europe in the agricultural sector.

Considering the fact that the first notifications of insect resistance to insecticides having developed as the result of practical controls are all based on field observations, it is necessary to emphasize that every report of such development must be checked very critically. Resistance is often thoughtlessly spoken of when the expected efficacy has not been obtained, although the reason for this was due to faulty implementation of controls. Only comparative studies in satisfactory controlled conditions will produce definite proof of resistance.

The first question that arises concerns the origin and development of resistance:

Resistance to a poison may theoretically develop in 3 ways, firstly by selection of the most resistant members of a population whereby the poison constitutes a selective agent (preadaptive), secondly due to a specific reciprocal action between chemical and organism whereby the chemical would be regarded as a mutagenous agent. The third possibility that organisms become accustomed to chronic-sublethal dosages, such as brought about in former years in *Paramecium* with arsenic and referred to as permanent modification, is today generally regarded as completely unlikely, and is not taken into consideration (postadaptive). At all events, large-scale studies of this question produced no indication whatsoever of acquired or induced resistance. Without entering into details about the studies conducted to settle this question, it may be stated that all results unanimously support the view that the development of resistance is a selection phenomenon. The insecticide acts like a screen which picks out the resistant members of a population. Accordingly, individuals of greatly varying susceptibility must already be present in the initial population. The poison eliminates the susceptible individuals while those that tolerate the poison survive, participating with increasing abundance in the reproduction process. The almost simultaneous occurrence of resistant flies and spider mites in wide and completely separated regions strengthens the assumption that the resistance is due to an intensive selection of naturally occurring mutants which apparently may develop in the pest populations, and also underlines the ease with which resistance may be produced in the laboratory. The intensity of the development of resistant populations depends upon the frequency of occurrence and the efficacy of resistant genes in natural populations, the intensity of selection and the number of generations. The assumption that insecticides might cause mutations is refuted, *inter alia*, by the fact that mutations occur spontaneously and not by external intervention. Several factors indicate that not necessarily all insect populations contain individuals with hereditary genes for resistance. The author is fully familiar with an interesting case where the fruit tree red spider mite developed a high degree of resistance in only 1 of 2 closely neighbouring orchards, while there were no signs whatsoever of resistance in the other

orchard even though both orchards had practically the same treatments. Furthermore, carefully conducted observations of my own and information from reliable experts in orchard fruit and hop-growing districts in Germany and Italy have confirmed that with practically the same acaricidal treatment schedule in all areas, development of resistance differs greatly from one locality to another. This finding was ratified in exact laboratory tests using different origins. Reports are also on hand from India, Japan and Ceylon, according to which no signs of fly resistance were established following application of dichlorodiphenyltrichloroethane over a period of many years. Even though such findings based on field observations must be treated with the necessary amount of criticism, they nevertheless leave no doubt as to the fact that intensity and speed of resistance development may apparently vary very considerably.

One may, therefore, justly assert that the insecticides are to be regarded as selective agents.

Accordingly, the same process takes place in the development of insect resistance to insecticides as in the biological specialization through the cultivation of bred resistant varieties of crops. Here, too, we are faced by the fact that every resistant variety eliminates those physiological strains harmless to it, and on the other hand stimulates development and multiplication of those by which it may be attacked. The increased cultivation of bred resistant varieties accelerates this process in that it provides unfavourable nutrient medium for the old strains, and an adapted but very favourable nutrient substratum for the new ones.

The best information on the development of insect resistance to insecticides is supplied by laboratory experiments carried out in carefully controlled conditions.

According to such experiments, the development of resistance in the house fly is brought about under the influence of a continuous selection in 2 different phases:

1. In about the first 10 generations, there is a slow selection to build-up of a resistance 5 to 10 times greater than normal.
2. Then follows a rapid increase of resistance with every generation until it finally grows to a level 100 to 1000 times greater than normal resistance after a further 20 generations.

A most outstanding feature is the leap in resistance at the start of the second phase. It is not, as originally assumed, due to a mutagenous effect of the insecticide but rathermore indicates selection from a gene which initially was very rare. "Theoretically", Wiesmann states, "one should, after sufficiently long selection, obtain homozygosis for the gene resistance, so that also after the selective agent ceases to act, resistance would be maintained". — Statements so far made on the origin and development of insecticide-resistance, also apply to acaricide-resistance, as shown by findings obtained and as already intimated.

Studies on the development of resistance also raise the question as to whether a resistance already existing to an insecticide has an influence on the development of resistance to another active material, in other words whether existing resistance creates predisposition for accelerated development of resist-

ance to other insecticides. In this respect, experience has been chiefly accumulated for the house fly, positively showing that once resistance has developed to dichlorodiphenyltrichloroethane, resistance to other chlorinated hydrocarbons such as BHC, dieldrin, methoxychlor, chlordane and toxaphene also follows shortly afterwards. In some areas, flies resistant to dichlorodiphenyltrichloroethane were in fact found to be simultaneously resistant to these other compounds although they had not previously been in contact with these active materials. However, considerable local differences apparently exist here. This so-called multiple or polyvalent resistance is today widespread in the Scandinavian countries, Italy, Sardinia, North, South and Central America and in the British Isles.

At all events, there is appreciable evidence at hand to support the belief that existing resistance to an insecticide creates predisposition for accelerated development of resistance to other active materials possessing the same or a similar mode of action. This applies at least to flies and spider mites, and to the hitherto examined active substances.

The other important question as to whether the insect and mite species known to be capable of developing resistance, are also capable of developing resistance to all poisons, must be answered in the affirmative according to our present level of knowledge. However, the speed and intensity with which resistance develops is apparently product-specific. Gasser stresses that spider mites are capable of setting defence mechanisms in action and forming resistant strains not only against organophosphorus compounds but also against specific acaricides. The same applies to house flies. It has, however, been proved that flies develop resistance to organophosphorus compounds and pyrethrum at a slower rate than against chlorinated hydrocarbons. There appear to be no appreciable differences among the various chlorinated hydrocarbons; likewise, it seems that no qualitative differences exist among the organophosphorus compounds in respect of spider mites, although apparently there are quantitative differences. In flies, the process of resistance development is faster when the larvae are exposed to the poison than when the imagines are treated. In spider mites, resistance develops more quickly after treatment of the eggs than after exposure to poison of the post-embryonic stages.

Stability of resistance

A factor of fundamental importance to practical controls is the answer to the question as to whether and to what extent, by suspending applications of an insecticide, in other words stopping the influence of the selective agent, there will or not be a return to the former susceptibility or a lessening of resistance, in other words the question of the stability of resistance. Studies so far conducted supply conflicting results, and in fact they must differ. The results of laboratory experiments on flies and spider mites and on the scale species *Aonidiella aurantii* support the belief that resistance is very stable.

Field studies, on the other hand, all furnish results which suggest a decrease of resistance and a division of the populations into resistant and non-resistant groups. Cutright established that after parathion-resistant fruit tree red spider mites had not been exposed to parathion treatment for 2 consecutive years, they again became susceptible to the active material in the

third year. Similar observations were made for flies and chlorinated hydrocarbons. The differences between the findings in the laboratory, on the one hand, and those in the field, on the other hand, may be attributed to the fact that the degree of resistance to insecticides and thus the homogeneity of the resistant strains apparently differed in the observed populations. At all events, one must in theory reckon with the possibility that homozygosis for resistance prevails when selection is complete, and thus so does the highest degree of stability. Changes are then merely a function of the rate of mutation. In practice, however, the situation may be completely different. Geneticists have stated that a lessening of resistance is probable because the genes for resistance must to a certain degree be harmful to a population.

Several observations support these intellectual arguments that resistant populations come through badly in the battle for existence. In this respect, we shall still have to reckon with great surprises, as revealed by current studies.

Heredity of resistance

Much study work has been done on the heredity of resistance, especially of dichlorodiphenyltrichloroethane-resistance in the house fly whereas there are only few data on heredity of resistance to acaricides. However, we are still very far from obtaining a solution in either case. Some authors maintain that resistance is linked with several genes, others state that a dominant gene is involved, while there are some who believe a single recessive gene is responsible, and finally reference is made to cycloplasmatic heredity or a combination of different mechanisms. Several reasons may be put forward to account for these notable differences:

1. The various strains actually possess different mechanisms of heredity.
2. The genetic fundamentals of the studied species are not completely known.
3. Different criteria have been applied for determining the degree of resistance. It is known, for example, that when initial toxicity is used as a standard, this apparently follows other heredity laws than mortality.
4. The working technique was not always completely satisfactory.

Taylor and Smith (1956), on the basis of their studies, are of the opinion that the resistance of the spider mite species *T. bimaculatus* to malathion is a dominant character, and probably due to a single factor. Transmission is stated to be from both sexes. According to the results of our own tests, we are inclined to agree on the whole with this view. Nevertheless, this question which has great bearing on the spread of resistance from treated to untreated areas, must for the time being also remain without a definite answer.

Types of resistance

No mention has so far been made of the possibilities the insect has of setting defence mechanisms in action. One distinguishes between the following mechanisms that provide the basis for resistance:

1. Physiological resistance, understood to mean the ability to resist a poison that has entered the organism, by means of biochemical processes.
2. Morphological resistance. Poison is prevented by morphological structures from entering the body.
3. Resistance determined by behaviour. The behaviour of the insect undergoes a change in that the individuals avoid contact with or uptake of the poison. To my knowledge, only 2 examples of this are known: — codling moth resistance to arsenic is said to be due to the rejection of the first bites by the larvae when they tunnel into the fruit, and the resistance of *Anopheles albimanus* which has developed hypersensitivity to residues of dichlorodiphenyltrichloroethane. An important task is to establish the type of resistance in each particular case.

Biochemistry of resistance

A knowledge of the biochemical processes responsible for resistance is of fundamental importance to the development of products for dealing with physiological resistance. For this reason, special attention has been given to the clarification of these processes. Our most reliable knowledge is in connection with dichlorodiphenyltrichloroethane whereas practically nothing is certain about the data accumulated for the other active materials. This is not surprising considering that our knowledge on the mechanism of action of the latest insecticides and acaricides is still very far from complete. But even in the case of dichlorodiphenyltrichloroethane, it has become clear that the resistance phenomenon is very complex and complicated, and that a final solution is still wanting. Nevertheless, a few important processes are already known. However, it is evident that the knowledge of these has so far not provided any genuine constructive contributions towards solving the problem of resistance.

Brief reference will now be made to a consequence that has arisen out of insect resistance to insecticides with respect to classification, and to which Hennig (1957) recently drew attention. He states that determination of the species is not enough for many purposes because we have realised the importance of the complicated intraspecific structure of many species. In many cases, it is no longer sufficient to distinguish according to morphological criteria because groups which as dead individuals show no morphological differences and hence are not distinguishable, do differ in their mode of life. Insect resistance to insecticides has brought interest to focus on these problems. It is known of the different strains that they feature a complicated intraspecific structure. "Classification is in a peculiar situation in view of all these complicated and unsolved cases".

At all events, we do not yet know whether morphological changes will also appear in course of time under the influence of the changed reaction standard. Occasionally, however, the view has been expressed that resistant mites are distinguishable from non-resistant mites. Exact studies will have to be carried out to investigate this.

A review of the present state of resistance to insecticides and acaricides would be incomplete and unsatisfactory if at least a brief comment were not to be given on the question of practical importance as to what can be done from

the aspect of control techniques in the areas of threatened resistance to insecticides and acaricides. Firstly, one may hope that the chemical industry will succeed in continually developing new insecticides and acaricides specially for use against the resistant species. So far there have been no serious gaps in the range products thanks to intensive research work, and the development of active materials has still continued to maintain its lead over the development of resistance. This will also remain so as long as active materials with a mechanism of action of a different kind can continually be discovered. On the grounds of theoretical deliberations, particular progress is expected from such substances which act more strongly on resistant strains than they do on strains of normal susceptibility.

Another possibility of drawing near to a solution of the problem of resistance is envisaged in a methodical, rotational use of control products having different modes of action, designed to defer or even prevent the selection processes for resistance. Cutright believes he has produced sound evidence of this. He found that there was no resistance in 3 orchards where, for various reasons, rotational use of active materials had regularly taken place, while on the other hand there was marked resistance of spider mites in orchards where no rotational use of active materials had been made. Great hopes may be placed in combinations of active materials with varying mechanism of action. At all events, it may be taken as certain that combinations of antibiotics and bactericides have proved to be effective against development of resistance in microorganisms.

With this general treatment of the subject, I hope to have succeeded in demonstrating the importance of the problem of resistance and depicting the present level of knowledge on the subject. The described examples may be regarded as very serious but they need not give cause to an air of panic. Here, one may agree with the view of Metcalf that the percentage of resistant species is very small in relation to the total number of major insect species, estimated at about 5000, and that resistance development may be regarded rather as an exception than as a regular occurrence. There are reliable indications that by no means all insect species are biochemically capable of developing resistance to certain active materials or groups of active substances. This is supported by the fact that in regions where the house fly has become highly resistant to dichlorodiphenyltrichloroethane, other fly species have remained normally susceptible, for example *Muscina stabulans*, *Callitroga macellaria* and *Phormia regina*. Similar differences have been established for the body louse (*Pediculus humanus corporis*) and the head louse (*Pediculus humanus capitis*). But also in agriculture, it has been registered that under otherwise like conditions it is always only in certain regions that particular species have a tendency to develop resistance, while most pests retain their normal susceptibility.

References

1. Braun, H.:
„Resistenzzüchtung und biologische Spezialisierung.“ — Naturwiss. Rundschau 1950, 403—409.
2. Cutright, C. R.:
“A three-year field study of a mite population resistant to Parathion.” — Res. Circ. Ohio Agr. Exp. Sta. No. 37, 1—12, 1956.

3. Cutright, C. R.:
"Rotational use of spray chemicals in insect and mite control." — Journ. Econ. Ent. 52 (1959), 432—434.
4. Gasser, R.:
„Über den Stand der Resistenz von Spinnmilben gegenüber Akariziden.“ — Kurzfassg. Vortrag Int. Pflanzenschutz-Kongress Hamburg 1952.
5. Hennig, W.:
„Systematik und Phylogenese.“ — Ber. Hundertjahrfeier Dt. Ent. Ges. Berlin 1957, 50—71.
6. March, R. B.:
"The biochemistry of resistance to organophosphorus compounds." — Pan American Health Organization, Final Rep. Panama 1958.
7. Metcalf, R. L.:
"Physiological basis for insect resistance to insecticides." — Phys. Rev. 35 (1955), 197—232.
8. Taylor, E. A., and Smith, F. F.:
"Transmission of resistance between strains of two-spotted spider mites." — Journ. Econ. Ent. 49 (1956), 858—895.
9. Wiesmann, R.:
„Das Problem der Insektizidresistenz.“ — Anz. für Schädlingkunde 30 (1957), 2—7.

On the joint control of mangold fly and aphis species on beets, with **LEBAYCID®**

by W. Kolbe, Leverkusen

Mangold fly (*Pegomyia betae* Curt.) and the aphis species *Myzodes persicae* Sulz. and *Aphis (Doralis) fabae* Scop. are dreaded pests of beet crops in Europe: — the larvae of mangold fly because they tunnel in the leaves often severely damaging or destroying young beet plants in particular, and the aphis species because they are carriers of beet yellows and also cause considerable harm by feeding on the leaves.

Control of mangold fly has been a serious problem ever since the early days of sugar beet and mangel cultivation for the economic damage, especially that resulting from early infestation by the 1st generation, may be most considerable. Bremer (6) estimated a beet yield decrease of 16 % due to mangold fly infestation, Kersting (14) 30 %, Koltermann (16) 20 to 30 % and Winner (29) 10 %, observations confirmed by Jones and Dunning (11) who, in their studies in England, established yield decreases of up to 11 %.

® = Registered trade mark of Farbenfabriken Bayer Aktiengesellschaft

Interest first became focussed on the control of aphid species following the spread of beet yellows; the major carriers of this virus disease are peach-potato aphid or green peach aphid (*Myzodes persicae* Sulz.) and black bean aphid (*Aphis* [D.] *fabae* Scop.), known since 1934/35. The heavy yield losses that are expected on a varying scale every year in the West European regions of yellows incidence, have led to exhaustive studies being carried out to investigate the subject of vector control (25). Even in years when there was less severe incidence of yellows, such as in 1955 and 1956, maximum yield decreases brought about by this disease amounted to 17 % for beets, 20 % for sugar and 6 % for leaf tops, plus a reduced sugar content of 0.5 %. These figures were recorded by Steudel and Blaesen (24) in tests carried out in scattered parts of the Federal Republic of Germany. Hull (9) obtained similar results in tests conducted in England in 1958.

Apart from these considerable yield losses indirectly caused by aphids acting as carriers of virus yellows, the direct damage inflicted by aphids feeding on the plants may also be great. Whereas *M. persicae*, by virtue of more intensified transmission, plays a greater part than *A. fabae* in the spread of virus yellows, the position is reversed with respect to feeding damage for here *A. fabae* causes more harm than *M. persicae*. In the event of mass multiplication, *A. fabae* severely harms beet seed by attacking the panicles* and the young beet plants; the result of such attacks is leaf curling and rolling of the leaf blade, followed by poor plant growth. Studies conducted by Kennedy have revealed that the physiological condition of young leaves is especially preferred by aphids — Börner and Schilder (5) also refer to this — so that mass multiplication of *A. fabae* frequently takes place on young beet plants, and may continue as long as the physiological condition of the leaves remains attractive to the aphids (3). Kennedy and Booth (13) observed that after the physiological condition of the leaves changes, winged aphids develop on an increasing scale so that in consequence the population becomes smaller on older leaves, furthermore the aphids migrate on the plants from older to younger leaves. Kennedy (12) also observed that the period of physiological aptitude of leaves for aphid multiplication is apparently prolonged by virus diseases.

Experimental studies arranged with the object of establishing the scale of yield decreases caused by aphids feeding on beets, are known to have been carried out so far only by Steudel and Blaesen (23) in 1954 and 1956. Earlier authors including Molz (18), Börner and Janisch (4), Janisch (10) and Börner and Schilder (5), who dealt with damage caused by mass multiplication of *A. fabae* on beets, in papers published in 1917, 1922, 1926 and 1932, laid emphasis, among other things, on the failure of controls due to the poor action of available products and because of the technical difficulties encountered in practice. Investigations into the extent of feeding damage met with difficulties in earlier days solely from the product aspect because the conventional contact aphicides used at that time had little effect especially when the aphids lived concealed in the plant parts they had deformed (on beets, particularly after rolling of the leaf blade). On the other hand, the amount of damage caused was adequately reflected in the deformation of the beet plants and the poor growth.

* Blaszyk (2) estimates that yield losses in beet seed growing, caused by feeding damage when there is mass multiplication of *A. fabae* in "aphis years", amounts to 50 %.

Steudel and Blaesén (23) in their studies, calculated the amount of feeding damage caused by *A. fabae*, by carrying out periodical sample uprootings to compare the yields of plots treated with METASYSTOX® with the yields of untreated check plots heavily infested by aphids. It was found that the yield losses, especially for tops, were greatest in summer and diminished towards the autumn. Nevertheless, when the harvest was finally reaped in October, losses caused by feeding damage amounted to 5 % for the beet yield, 6 to 7 % for the sugar yield and 4 to 8 % for the leaf yield. Steudel and Blaesén (23) also carried out greenhouse tests to establish the influence of mass *A. fabae* infestation on the development of virus-free and yellows-infected beets. In these tests, an 11 % beet yield decrease was registered for beet plants damaged by *A. fabae* feeding, 43 % yield decrease for beets infected with virus yellows transmitted by *M. persicae*, and 58 % yield decrease for beet plants simultaneously damaged by *A. fabae* feeding and infected by yellows virus transmitted by *M. persicae*, in other words the stunting of beet growth caused by *A. fabae* feeding stimulated susceptibility to virus infection and increased the yield losses. It should furthermore be mentioned that yield decreases caused by feeding damage and virus infections may also be considerably raised by mangold fly infestation.

Prevention of yield losses which aphids cause by transmitting virus yellows and by feeding on the plants, has become possible in the past 10 years largely due to the use of systemic insecticides such as SYSTOX® and METASYSTOX which have a very long residual action (21, 1). The problem of controlling mangold fly has also been largely solved by the application of organophosphorus compounds (e. g. DIPTEREX®) and chlorinated hydrocarbons (e. g. Endrin) (17, 15).

Difficulties arise from the product aspect when aphid species and mangold fly occur together. As Koltermann (16) emphasizes, all mangold fly control products have the disadvantage that, at the recommended concentrations, they have little or no effect against aphid species. Likewise, the systemic insecticides used for controlling aphids, only bring about a temporary reduction of mangold fly infestation (15) or rather more lower the extent of damage caused by this pest (24), but do not have an adequate residual effect for it to be fully controlled (8). E 605® and diazinon which are simultaneously effective against mangold fly and aphid species, are not persistent enough (1, 15).

In recent years, the corresponding products used for controlling mangold fly and aphid species, have, therefore, frequently been applied in combined sprays to combat simultaneous occurrence of these 2 pests. For instance, regularly applied combinations such as 800—600 ccs/ha of METASYSTOX (i) + 300 g/ha of DIPTEREX Wettable Powder resp. 300 ccs/ha of DIPTEREX Emulsion gave a 100 % mangold fly mortality apart from controlling aphid, with a satisfactory residual action (15). Further possibilities of jointly controlling both pests are offered by treating seed with DISYSTON®, a systemic insecticide which in beet growing, can be drilled into the soil in a granular formulation mixed with the seed, or added to the seed by drilling. DISYSTON protects the young beet plants against early infestation of mangold fly and aphids for 6 to 8 weeks after plant emergence, as proved by past tests (some of which have already been published) (22, 26, 27).

® = Registered trade mark of Farbenfabriken Bayer Aktiengesellschaft

In trials carried out in 1958 and 1959, it was also established that LEBAYCID, an organophosphorus compound of low mammalian toxicity developed by Schrader (20), has an excellent initial and residual action against both mangold fly and aphid species. Unterstenhöfer (28) found that the LD₅₀ for mangold fly larvae is 0.0003 % active ingredient, for mangold fly eggs 0.002 %, for *A. fabae* (on *Vicia faba*) 0.0007 %, for *M. persicae* (on *Brassica spec.*) 0.001 %. The results of field trials which will be discussed in the following sections, show that LEBAYCID gives a satisfactory effect also in practical conditions.

Formulation of the problem

The joint control of mangold fly and aphid species has become a matter of major interest especially in the last 4 to 5 years following the renewed epidemic expansion of the areas of mangold fly infestation. During 1959, a year of severe mangold fly and aphid infestation, 3 sprays were carried out on the general average in many regions, the 1st spray being applied only against mangold fly, the 2nd. spray against both mangold fly and aphid species, and the 3rd spray only against aphids. In numerous cases, a mangold fly control product with an aphicidal action could have been used in the 1st spray application because the peaks of the main infestation periods of both pests overlapped.

A point of probable interest in this connection is that the factors leading to a sudden mass multiplication of mangold fly and aphid species on an epidemic scale are difficult to establish so that infestation forecasts, in particular, are very uncertain. For example, the statistical evaluations of Bremer and Stapel (7), based on many years of infestation estimates in Denmark, and according to which up to 1940 low summer temperatures constituted a condition for an epidemic mass reproduction of mangold fly in the following year, showed that since 1940 these temperature relations no longer exist and severe infestation occurs also following years of supernormal summer temperatures. As the forecast of mangold fly infestation, based on the population density of pupae or the severity of autumn infestation by the 3rd generation, likewise provides indications of only limited usefulness, there may be years which surprisingly develop into a "mangold fly year".* Similar observations were made by Steudel and Blaesén (24) for *A. fabae* — which, like the mangold fly, may occur on an epidemic scale throughout the whole of the Federal Republic — in 1956 when, despite "unfavourable weather conditions", the beet fields in large parts of the Federal Republic (Upper Rhine Valley, Kurhessen, North Rhine) were severely colonized by *A. fabae* whereas the heavy occurrence of *M. persicae*, as in all years, was confined more to certain areas (24).

* Mangold fly which, since 1954, is again spreading from Mecklenburg and Vorpommern, causing severe damage in recent years in North and West Germany, has meanwhile occurred also in South Germany (Rheinland-Pfalz [19], Baden-Württemberg and North Bavaria) with epidemic outbreaks of mass reproduction (30). Similar expansions of infestation zones were observed in France (17). According to Gersdorf (8a) occurrence of mangold fly in Lower Saxony is not expected in 1960 due to heavy parasitization.

For such cases where epidemic mass reproductions of mangold fly and aphid species coincide or overlap, a product is needed which gives simultaneous control of both pests. In our trials conducted in 1958 and 1959, the action of LEBAYCID which, as already mentioned, features among other things a good aphicidal effect and gives control of mangold fly, was, therefore, especially tested in comparison with conventional products applied against aphid and mangold fly.

The different questions that had to be settled were as follows:

Effect against mangold fly

Does LEBAYCID correspond in its residual action to the conventional DIPTEREX formulations?

Can the residual action of LEBAYCID be prolonged by raising the dosages?

How does LEBAYCID behave in comparison with other mangold fly control products?

Are there any differences in the effect against mangold fly among the systemic insecticides used for controlling aphids?

Effect against aphids

How does the residual action of LEBAYCID compare with that of the systemic insecticides?

Can the residual action of LEBAYCID be prolonged by raising the dosages?

Is LEBAYCID, by virtue of its residual action established in comparison with the systemic insecticides, also suitable for use in areas of yellows incidence, when mangold fly has to be controlled at the same time as yellows vectors?

1958 was a year of moderate mangold fly occurrence and slight aphid infestation, whereas in 1959 there was widespread mass reproduction of both mangold fly and aphid species providing stringent test conditions with heavy infestation density.

Arrangement and evaluation of tests*

The mangold fly trial controls were carried out as small and large plot tests in both years (1958 and 1959), being held in the Siegburg district; the aphid trials, also arranged as small and large plot tests, took place in Leverkusen and Siegburg. The details of the tests are as follows (dosages refer to product):

Testing action against mangold fly

Test 1:	Date: June 2, 1958. Place: Gutshof Frenger-Esser, Kriegsdorf, Siegburg district. Crop.: sugar beets. Sprayer: Holder type higher-pressure knapsack sprayer. Rate of application: 400 litres/hectare. Size of plot: 50 square metres.
---------	--

* I am especially grateful to N. Trierweiler, Siegburg district extensionist of the Crop Protection Office, Bonn, for his kind assistance in selecting the test sites.

Weather: dry, sunny, min. temp. 15° C, max. temp. 29° C, no wind.

Products:	LEBAYCID-Emulsion	600 ccs/ha
	CHLORTHION®-Emulsion*	600 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	Thiometon	600 ccs/ha
	DICONTAL®-Emulsion	600 ccs/ha
	METASYSTOX (i)	800 ccs/ha
	Hexachlorobicyclo-2-heptene-5,6-bis-oxymethylenesulphite	2500 ccs/ha
	Lindane + dichlorodiphenyl-trichloroethane + dieldrin	500 ccs/ha
	METASYSTOX (i) +	800 ccs/ha +
	DIPTEREX-Emulsion	300 ccs/ha
	METASYSTOX (i) +	800 ccs/ha +
	DIPTEREX-Emulsion	150 ccs/ha
	METASYSTOX (i) +	400 ccs/ha +
	DIPTEREX-Emulsion	300 ccs/ha
	CHLORTHION forte	600 ccs/ha
	Untreated check	

Test 2: Date: June 2, 1958. Place: Gutshof Frenger-Esser, Kriegsdorf, Siegburg district. Crop: sugar beets. Sprayer: Holder type (Auto-Rekord) triple-plunger sprayer. Rate of application: 400 litres/hectare. Size of plot: 3000 square metres.

Weather: dry, sunny, min. temp. 15° C, max. temp. 29° C, wind force 1.

Products:	LEBAYCID-Emulsion	600 ccs/ha
	CHLORTHION-Emulsion**	600 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	Thiometon	600 ccs/ha
	DICONTAL-Emulsion	600 ccs/ha
	METASYSTOX (i)	800 ccs/ha
	Hexachlorobicyclo-2-heptene-5,6-bis-oxymethylenesulphite	2500 ccs/ha
	Lindane + dichlorodiphenyl-trichloroethane + dieldrin	500 ccs/ha
	METASYSTOX (i) +	800 ccs/ha +
	DIPTEREX-Emulsion	300 ccs/ha
	METASYSTOX (i) +	400 ccs/ha +
	DIPTEREX-Emulsion	150 ccs/ha
	Untreated check	

Test 3: Date: June 2, 1958. Place: Zissendorf (Dr. Warstat-Erben), Hennef, Siegburg district. Crop: sugar beets. Sprayer: Platz type mounted sprayer with triple-plunger pump. Rate of application: 440 litres/hectare. Size of plot: 2000 square metres.

Weather: dry, cloudy, min. temp. 15° C, max. temp. 29° C, wind force 1--2.

Products:	LEBAYCID-Emulsion	600 ccs/ha
	CHLORTHION-Emulsion*	600 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	Thiometon	600 ccs/ha
	DICONTAL-Emulsion	600 ccs/ha
	METASYSTOX (i)	800 ccs/ha
	Hexachlorobicyclo-2-heptene-5,6-bis-oxymethylenesulphite	2500 ccs/ha

* = Registered trade mark of Farbenfabriken Bayer Aktiengesellschaft

* Test No. 4695

Lindane + dichlorodiphenyl- trichloroethane + dieldrin	500 ccs/ha
METASYSTOX (I) +	800 ccs/ha +
DIPTEREX-Emulsion	300 ccs/ha
METASYSTOX (I) +	400 ccs/ha +
DIPTEREX-Emulsion	150 ccs/ha
Untreated check	

Test 4: Date: May, 9, 1959. Place: Gut Zissendorf (Dr. Warstat-Erben) Hennef, Siegburg district. Crop: sugar beets. Sprayer: Platz type mounted sprayer with triple-plunger pump. Rate of application: 600 litres/hectare. Size of plot: 2500 square metres.

Weather: sunny, mean temp. 17.9° C, 65% r. h.

Products:	LEBAYCID-Emulsion	600 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	METASYSTOX	800 ccs/ha
	METASYSTOX (I)	800 ccs/ha
	N-methyl-1-naphthylcarbamate	900 g/ha
	Thiometon	800 ccs/ha
	METASYSTOX R	800 ccs/ha
	GUSATHION® A	600 ccs/ha
	Hexachlorobicyclo-2-heptene- 5,6-bis-oxymethylenesulphite	2500 ccs/ha
	DIPTEREX-Emulsion	300 ccs/ha
	LEBAYCID-Emulsion	1200 ccs/ha
	METASYSTOX (I) +	600 ccs/ha +
	DIPTEREX-Emulsion	300 ccs/ha
	LEBAYCID-Emulsion	600 ccs/ha
	LEBAYCID-Emulsion	900 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	Untreated check	

Test 5: Date: May 13, 1959. Place: Gutshof Frenger-Esser, Kriegsdorf, Siegburg district. Crop: sugar beets. Sprayer: Holder type (Auto-Rekord) triple-plunger sprayer. Rate of application: 400 litres/hectare. Size of plot: 2000 square metres.

Weather: sunny, mean temp. 13.3° C, 57% r. h.

Products:	LEBAYCID-Emulsion	600 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	METASYSTOX	800 ccs/ha
	METASYSTOX (I)	800 ccs/ha
	N-methyl-1-naphthylcarbamate	900 g/ha
	Thiometon	800 ccs/ha
	METASYSTOX R	800 ccs/ha
	GUSATHION A	600 ccs/ha
	Hexachlorobicyclo-2-heptene- 5,6-bis-oxymethylenesulphite	2500 ccs/ha
	LEBAYCID-Emulsion	1200 ccs/ha
	LEBAYCID-Emulsion	900 ccs/ha
	LEBAYCID-Emulsion	600 ccs/ha
	DIPTEREX Soluble Powder	600 g/ha
	DIPTEREX Soluble Powder	300 g/ha
	METASYSTOX (I) +	600 ccs/ha +
	DIPTEREX-Emulsion	300 ccs/ha
	Untreated check	

Test 6: Date: May 16, 1959. Place: Gutshof Frenger-Esser, Kriegsdorf, Siegburg district. Crop: sugar beets. Sprayer: Holder type p. t. o. sprayer. Rate of application: 600 litres/hectare. Size of plot: 1500 square metres.

® = Registered trade mark of Farbenfabriken Bayer Aktiengesellschaft.

Weather:	sunny, mean temp. 9.2° C, 88 % r. h.	
Products:	LEBAYCID-Emulsion	600 ccs/ha
	DIPTEREX-Emulsion	600 ccs/ha
	GUSATHION A	600 ccs/ha
	LEBAYCID-Emulsion	600 ccs/ha
	LEBAYCID-Emulsion	900 ccs/ha
	LEBAYCID-Emulsion	1200 ccs/ha
	DIPTEREX Soluble Powder	600 g/ha
	DIPTEREX-Emulsion	300 ccs/ha
	METASYSTOX (i) +	600 ccs/ha +
	DIPTEREX-Emulsion	300 ccs/ha
	Untreated check	

Testing action against aphids*

Test 7: Date: July 7, 1958. Place: Kurtkottenhof, Leverkusen. Potato variety: Ackersegen. Sprayer: Platz type mounted sprayer with triple-plunger pump. Rate of application: 600 litres/hectare. Size of plot: 2000 square metres.
Aphis species: *Myzodes persicae* and *Macrosiphon solani*.

Weather: overcast, max. temp. 24.3° C, min. temp. 10.9° C, mean temp. 18.3° C, 89 % r. h.

Products:	LEBAYCID-Emulsion	500 ccs/ha
	4891a	600 ccs/ha
	METASYSTOX (i)	800 ccs/ha
	4859	600 ccs/ha
	4892	600 ccs/ha
	LEBAYCID-Emulsion	800 ccs/ha
	Untreated check	

Test 8: Date: June 5, 1959. Place: Landwirt Klein, Buisdorf, Siegburg district. Crop: Sugar beets. Sprayer: Metzinger type vine sprayer. Rate of application: 800 litres/hectare. Size of plot: 50 square metres with 2 replications = 100 square metres.
Aphis species: *Myzodes persicae* and *Aphis* (D.) *fabae*.

Weather: sunny, max. temp. 28° C, min. temp. 12.7° C, mean temp. 20.4° C, 57 % r. h.

Products:	METASYSTOX	800 ccs/ha
	METASYSTOX (i)	800 ccs/ha
	METASYSTOX (i)	400 ccs/ha
	METASYSTOX R	800 ccs/ha
	METASYSTOX R	400 ccs/ha
	LEBAYCID-Emulsion	800 ccs/ha
	LEBAYCID-Emulsion	1600 ccs/ha
	N-methyl-1-naphthylcarbamate	1600 g/ha
	Fluoroacetamide	1320 ccs/ha
	LEBAYCID-Emulsion	400 ccs/ha
	LEBAYCID-Emulsion	600 ccs/ha
	LEBAYCID-Emulsion	800 ccs/ha
	Untreated check	

Test 9: Date: June 4, 1959. Place: Kurtkottenhof, Leverkusen. Potato variety: Erstling. Sprayer: Holder type high-pressure knapsack sprayer. Rate of application: 800 litres/hectare. Size of plot: 60 square metres.
Aphis species: *Myzodes persicae* and *Macrosiphon solani*.

* Some of the aphis control trials were carried out on potatoes in order to obtain comparative values for other plants.

Weather:	sunny, max. temp. 25.1° C, min. temp. 12.8° C, 61% r. h.	
Products:	METASYSTOX	800 ccs/ha
	METASYSTOX (i)	800 ccs/ha
	METASYSTOX (i)	400 ccs/ha
	METASYSTOX R	800 ccs/ha
	METASYSTOX R	400 ccs/ha
	LEBAYCID-Emulsion	800 ccs/ha
	LEBAYCID-Emulsion	1600 ccs/ha
	N-methyl-1-naphthylcarbamate	1600 g/ha
	Fluoroacetamide	1320 ccs/ha
	Untreated check	

The mangold fly tests were evaluated at 2-day intervals for a period of 2 weeks after spraying. In these evaluations, a given number of leaves heavily colonized with eggs and recently tunneled, were examined under a binocular for dead and live larvae. The mortality in the untreated check plots was so slight that it could be disregarded in the evaluation.

The aphid control trials were evaluated at intervals of 1 to 3 days for a period of up to 16 days after spraying. The number of aphids was counted on a given number of plants, leaves and shoots, respectively. The initial rate of infestation was very high for both *M. persicae* and *A. fabae* so that the initial action of the products could be well tested. Furthermore, as there was a very large number of winged aphids of both species in the check and peripheral plots during the period of the test, it was possible to observe, from re-colonization, the residual action of the products rather accurately.

Results

The most important object of testing the effect against mangold fly and aphids was to assess the residual action of the different products, especially that of LEBAYCID. For this reason, in supplement of the tests carried out with DIPTEREX in 1957 (15), LEBAYCID was also applied at staggered dosages in order to establish whether the residual action is prolonged as the concentration is raised.

Action against mangold fly

In the mangold fly control trials carried out in 1958 and 1959 (the results are given in Tables 1 to 6), the following products and active ingredients were tested:

Organophosphorus compounds

DIPTEREX*
LEBAYCID*
CHLORTHION*
DICONTAL*
GUSATHION A

Systemic insecticides

METASYSTOX
METASYSTOX (i)
METASYSTOX R
Thiometon

* Approved products for controlling mangold fly.

Table 1: Test No. 1 (Kriegsdorf, Siegburg district). Action of LEBAYCID and DIPTEREX against mangold fly in comparison with other mangold fly control products and systemic insecticides

Date of spraying: June 2, 1958	Dosage ccs/ha	1 day		3 days		5 days		7 days		9 days		14 days	
		No.1) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %	No.3) of larvae	Mor- tality in %	No.3) of larvae	Mor- tality in %	No.3) of larvae	Mor- tality in %
LEBAYCID-Emulsion	600	72	100	47	100	59	100	59	93	71	72	38	24
CHLORTHION- Emulsion*	600	121	99	46	100	108	100	88	71	59	59	53	6
DIPTEREX-Emulsion	600	91	100	51	100	84	100	66	100	83	100	27	67
Thiometon	600	51	41	81	58 ¹	110	44	93	25	63	30	41	5
DICONTAL-Emulsion	600	79	100	44	100	72	100	77	90	76	87	73	25
METASYSTOX (i)	800	140	70	83	83	132	51	103	26	95	19	63	2
Hexachlorobicyclo-2- heptene-5,6-bis-oxy- methylenesulphite	2500	45	40	76	90	124	89	90	91	38	42	31	19
Lindane + dichloro- diphenyltrichloro- ethane + dieldrin	500	129	73	84	93	122	93	88	92	55	87	65	52
METASYSTOX (i) + DIPTEREX-Emulsion	800 300	76	87	60	100	115	100	61	100	84	94	23	26
METASYSTOX (i) + DIPTEREX-Emulsion	800 150	160	94	106	100	112	97	63	81	74	81	51	18
METASYSTOX (i) + DIPTEREX-Emulsion	400 300	73	96	72	100	59	100	92	100	64	88	28	11
CHLORTHION forte	600	155	100	83	100	116	100	131	37	72	39	52	23

* Test No. 4695 ¹⁾ Number of larvae in 30 examined leaves ²⁾ in 25 leaves ³⁾ in 20 leaves

Table 2: Test No. 2 (Kriegsdorf, Siegburg district). Action of LEBAYCID and DIPTEREX against mangold fly in comparison with other products

Date of spraying: June 2, 1958	Dos- age ccs/ha	1 day		3 days		5 days		7 days		9 days		11 days		14 days	
		No.1) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %	No.3) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %	No.2) of larvae	Mor- tality in %
LEBAYCID-Emulsion	600	187	100	143	100	132	93	54	94	87	23	96	24	61	3
CHLORTHION- Emulsion*	600	68	74	73	100	125	98	113	63	85	32	70	11	69	1
DIPTEREX-Emulsion	600	88	99	78	100	68	99	76	100	101	68	61	54	82	22
Thiometon	600	138	25	86	49	115	29	135	20	80	13	70	4	79	4
DICONTAL-Emulsion	600	75	96	79	100	65	94	98	84	103	44	73	16	47	9
METASYSTOX (i)	800	75	61	93	62	155	23	163	11	166	14	49	2	54	9
Hexachlorobicyclo-2- heptene-5,6-bis-oxy- methylenesulphite	2500	105	41	99	67	100	46	94	28	57	68	112	28	82	2
Lindane + dichloro- diphenyltrichloro- ethane + dieldrin	500	46	15	52	71	124	67	124	23	106	51	52	12	45	7
METASYSTOX (i) + DIPTEREX-Emulsion	800 300	115	91	60	100	56	100	81	90	96	35	44	70	70	30
METASYSTOX (i) + DIPTEREX-Emulsion	400 150	61	93	68	100	60	57	100	57	80	23	98	33	57	32

* Test No. 4695 ¹⁾ Number of larvae in 30 examined leaves ²⁾ in 25 leaves ³⁾ in 20 leaves

Table 3: Test No. 3 (Zissendorf, Siegburg district). Action of LEBAYCID against mangold fly in comparison with other products

Date of spraying: June 2, 1958	Dosage ccs/ha	1 day		3 days		5 days		7 days		9 days		11 days		14 days	
		No. ¹⁾ of larvae	Mor- tality in %	No. ¹⁾ of larvae	Mor- tality in %	No. ¹⁾ of larvae	Mor- tality in %	No. ¹⁾ of larvae	Mor- tality in %	No. ¹⁾ of larvae	Mor- tality in %	No. ²⁾ of larvae	Mor- tality in %	No. ²⁾ of larvae	Mor- tality in %
LEBAYCID-Emulsion	600	52	96	82	100	87	100	86	85	66	100	30	90	40	15
CHLORTHION- Emulsion*	600	56	100	70	100	84	100	89	65	70	31	40	40	32	25
DIPTEREX-Emulsion	600	82	96	55	100	68	100	53	100	62	95	29	100	37	24
Thiometon	600	42	17	84	64	107	50	95	23	68	9	41	15	35	0
DICONTAL-Emulsion	600	45	100	117	100	123	100	87	100	102	99	30	97	30	27
METASYSTOX (i)	800	65	42	71	90	108	68	107	20	78	30	51	22	42	17
Hexachlorobicyclo- 2-heptene-5,6-bis-oxy- methylene sulphite	2500	74	16	68	87	60	77	50	66	52	87	42	83	43	30
Lindane + dichloro- diphenyltrichloro- ethane + dieldrin	500	56	11	49	94	101	97	84	100	47	100	46	94	42	33
METASYSTOX (i) + DIPTEREX-Emulsion	800 300	50	100	66	100	104	100	75	100	51	98	30	90	21	14
METASYSTOX (i) + DIPTEREX-Emulsion	400 150	41	88	53	100	76	100	71	97	75	79	41	44	34	38

* Test No. 4695 ¹⁾ No. of larvae in 25 examined leaves, ²⁾ in 15 leaves

Table 4: Test No. 4 (Zissendorf, Siegburg district). Action of LEBAYCID against mangold fly at staggered dosages in comparison with other products

Date of spraying: May 9, 1959	Dosage ccs/ha	1 day		3 days		5 days		7 days		10 days		13 days	
		No. ¹⁾ of larvae	Mor- tality in %	No. ²⁾ of larvae	Mor- tality in %	No. ²⁾ of larvae	Mor- tality in %	No. ³⁾ of larvae	Mor- tality in %	No. ³⁾ of larvae	Mor- tality in %	No. ³⁾ of larvae	Mor- tality in %
LEBAYCID-Emulsion	600	202	100	114	100	121	97	111	91	321	15	344	2
DIPTEREX-Emulsion	600	310	99	125	100	183	100	98	90	145	28	160	3
METASYSTOX	800	267	89	266	80	168	35	197	21	116	4	155	6
METASYSTOX (i)	800	293	91	208	64	251	22	90	26	224	4	141	8
N-methyl-1-naphthyl- carbamate	900 g	298	92	291	67	101	23	133	20	204	37	100	8
Thiometon	800	214	77	117	68	202	32	94	18	194	4	106	1
METASYSTOX R	800	400	98	237	92	112	51	64	83	248	19	87	0
GUSATHION A	600	206	100	112	100	141	100	67	100	90	19	98	2
Hexachlorobicyclo- 2-heptene-5,6-bis-oxy- methylene sulphite	2500	241	89	212	89	95	87	100	64	180	51	89	3
DIPTEREX-Emulsion	300	302	100	121	100	83	94	84	87	134	6	91	10
LEBAYCID-Emulsion	1200	191	100	127	100	116	100	87	100	122	32	134	29
METASYSTOX (i) + DIPTEREX-Emulsion	600 300	213	100	152	100	108	94	62	97	142	26	122	7
LEBAYCID-Emulsion	600	322	99	190	100	91	100	97	92	127	4	113	5
LEBAYCID-Emulsion	900	166	99	142	100	117	100	57	100	196	13	188	2
DIPTEREX-Emulsion	600	299	99	118	100	122	94	58	93	159	38	190	20

¹⁾ No. of larvae in 30 examined leaves, ²⁾ in 20 leaves, ³⁾ in 15 leaves

Table 5: Test No. 5 (Kriegsdorf, Siegburg district). Action of LEBAYCID against mangold fly in comparison with other products

Date of spraying: May 13, 1959	Dosage ccs/ha	1 day		3 days		5 days		7 days		10 days		13 days	
		No. ¹⁾ of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %
LEBAYCID-Emulsion	600	139	98	68	100	85	98	58	89	132	24	79	10
DIPTEREX-Emulsion	600	84	100	94	99	103	100	64	76	139	20	68	13
METASYSTOX	800	175	61	95	79	45	22	60	2	84	10	71	31
METASYSTOX (i)	800	106	18	91	57	120	30	59	3	39	0	69	10
N-methyl-1-naphthyl- carbamate	900 g	72	21	49	39	125	16	77	21	50	6	52	2
Thiometon	800	93	26	66	68	55	27	75	9	122	5	73	3
METASYSTOX R	800	66	42	93	92	48	71	64	45	102	7	49	33
GUSATHION A	600	156	97	94	100	82	99	54	19	93	11	64	19
Hexachlorobicyclo- 2-heptene-5,6-bis- oxymethylenesulphite	2500	76	33	57	86	107	31	46	26	120	28	44	9
LEBAYCID-Emulsion	1200	158	98	71	100	101	100	97	81	114	33	92	14
LEBAYCID-Emulsion	900	131	97	73	100	55	100	86	67	108	10	96	13
LEBAYCID-Emulsion	600	78	97	51	100	55	100	82	42	121	12	90	20
DIPTEREX Sol. Powder	600 g	90	100	56	100	60	100	121	87	127	43	96	18
DIPTEREX Sol. Powder	300 g	81	96	29	100	96	96	95	74	144	20	73	18
METASYSTOX (i) + DIPTEREX-Emulsion	600 300	87	89	50	96	90	98	91	81	173	47	96	21

¹⁾ No. of larvae in 25 examined leaves, subsequent counts on 15 leaves

Table 6: Test No. 6 (Kriegsdorf, Siegburg district). Action of LEBAYCID against mangold fly in comparison with DIPTEREX at different rates of application

Date of spraying: May 16, 1959	Dosage ccs/ha	2 days		4 days		6 days		9 days		11 days		14 days	
		No. ¹⁾ of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %	No. of larvae	Mor- tality in %
LEBAYCID-Emulsion	600	182	100	124	100	163	100	92	53	102	23	61	0
DIPTEREX-Emulsion	600	250	100	179	100	290	93	81	78	81	14	105	23
GUSATHION A	600	339	99	115	100	184	100	108	72	85	2	54	15
LEBAYCID-Emulsion	600	326	100	121	100	166	100	26	69	64	25	67	25
LEBAYCID-Emulsion	900	244	100	126	100	119	100	141	89	47	39	62	18
LEBAYCID-Emulsion	1200	254	100	122	100	182	100	83	77	59	37	71	42
DIPTEREX Sol. Powder	600 g	234	100	153	100	205	100	86	76	59	30	65	15
DIPTEREX-Emulsion	300	272	99	144	100	183	96	121	79	53	6	52	6
METASYSTOX (i) + DIPTEREX-Emulsion	600 300	356	96	148	100	253	100	59	81	48	29	51	6

¹⁾ No. of larvae in 15 examined leaves

Chlorinated hydrocarbons

Lindane + dichlorodiphenyltrichloroethane + dieldrin*
Hexachlorobicyclo-2-heptene-5,6-bis-oxymethylensulphite*

Carbamates

N-methyl-1-naphthylcarbamate

Combinations

METASYSTOX (i) + DIPTEREX

The tests aimed at comparing LEBAYCID with the other mangold fly control products, especially with DIPTEREX. Furthermore, the question had to be investigated whether differences in the action against mangold fly larvae exist among the systemic insecticides used in beet-growing for controlling

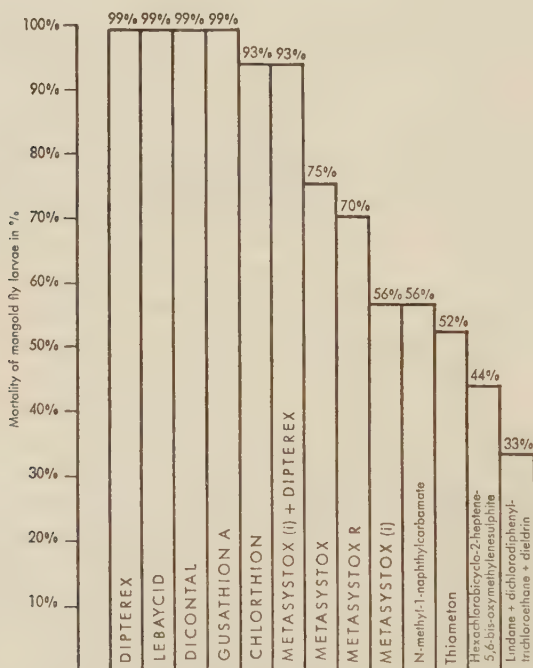


Fig. 1: Differences in initial action of various products against mangold fly larvae 24 hours after spraying. Mean values for all tests

aphids. As Fig. 1 shows with respect to initial toxicity, LEBAYCID, DIPTEREX, DICONAL and GUSATHION A give an immediate 100 % kill of mangold fly larvae whereas the systemic insecticides, chlorinated hydrocarbons and carbamates reduce infestation on the average by only 50 %.

In order to provide a general picture of the overall effect of the products, and especially of the residual action, an attempt has been made in Table 7 to

* Approved products for controlling mangold fly

combine the individual values for the different products, as listed in Tables 1 to 6, to give clearer averages. The percentage mortality of larvae established in the individual tests at intervals of 1—3, 4—6, 7—9, 10—12 and 13—15 days after spraying was averaged for each product, and then an overall mean, reflecting both the initial effect and the residual action, was calculated from all individual values for every preparation.

Table 7: Percentage mortality of mangold fly larvae at given intervals after spraying (averages for all tests; see Tables 1 to 6 for individual values).

	Dosage in ccs/ha	1—3 days	4—6 days	7—9 days	10—12 days	13—15 days	Overall average
Organophosphorus compounds							
DIPTEREX	600	100	99	87	41	23	76
DIPTEREX	300	99	97	80	11	11	66
LEBAYCID	600	99	99	70	27	12	70
LEBAYCID	900	99	100	85	21	11	69
LEBAYCID	1200	100	100	86	34	28	75
CHLORTHION*	600	97	100	50	26	14	64
DICONTAL*	600	99	98	84	58	20	79
GUSATHION A	600	99	100	64	11	12	64
Systemic insecticides							
METASYSTOX	800	77	29	12	7	19	37
METASYSTOX (i)	800	64	39	19	7	9	33
METASYSTOX R	800	81	61	64	13	17	53
Thiometon	800	42	41	20	10	3	30
Thiometon *	600	60	30	14	5	2	28
Chlorinated hydrocarbons							
Lindane + dichlorodiphenyl- trichloroethane + dieldrin*	500	60	86	76	53	31	63
Hexachlorobicyclo-2-heptene- 5,6-bis-oxymethylenesulphite	2500	64	66	59	48	13	53
Carbamates							
N-methyl-1-naphthylcarbamate	900	55	20	21	22	5	29
Combinations							
METASYSTOX(i) + DIPTEREX	**	96	87	84	48	20	75

* Tested only in 1958

** Average values for 9 combinations with varying added portions of METASYSTOX (i) (800, 600 and 400 ccs/ha, resp.) and DIPTEREX (300 and 150 ccs/ha, resp.)

In order to be able to make a better comparison of the residual action of the different products, we went one stage further than the above tabulated survey, and plotted in Fig. 2 the mortality percentages registered 5, 8 and 11 days after spraying, for the most important products. In comparison with the

initial action shown in Fig. 1, DIPTEREX and LEBAYCID also produced a good residual action (in contrast to the other preparations), although due to the heavy infestation density, and the unusually high temperatures in 1959, the persistence was shorter than in other years. Thus, a comparison of the residual action obtained for DIPTEREX in 1957, 1958 and 1959, and illustrated in Fig. 3, shows that there is a drop in the 1959 values. Examining the information provided by Fig. 3 more closely, and assuming < 50 % mortality of larvae to be the limit of the residual action, it is evident that DIPTEREX was nevertheless persistent for 11 to 12 days in 1957 and 1958, but for only 9 to 10 days in 1959. The reason for the shorter persistence established in 1959 may be attributed to

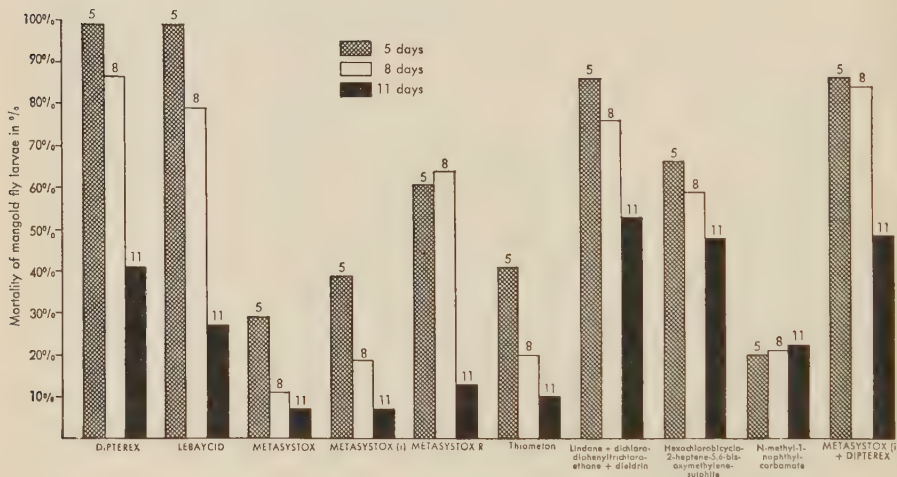


Fig. 2: Residual action against mangold fly (= mortality of larvae in %) after 5, 8 and 11 days for different products

the supernormal temperatures which cause a more rapid break-down of the active ingredient, just as for all organophosphorus compounds (18a). In addition to the temperature factor, there was the heavy infestation density. It is, however, noticeable also from the results of the 1957 tests (15) that a shorter residual action can generally be reckoned with as the temperature rises. Fig. 4b, plotted for Test No. 6 carried out in 1957 (15), shows that by raising the dosages, from 600 ccs/ha to 900 ccs/ha for DIPTEREX and from 400 ccs/ha to 600 ccs/ha for endrin, a longer residual action will not result when the temperatures are on the increase and the infestation density persists. Whereas DIPTEREX and endrin, as seen in Fig. 4a, had a long residual effect as based

* According to available results, METASYSTOX R gives better control of mangold fly than the other systemic insecticides. These results will be checked in the 1960 trial controls with variation of the dosages.

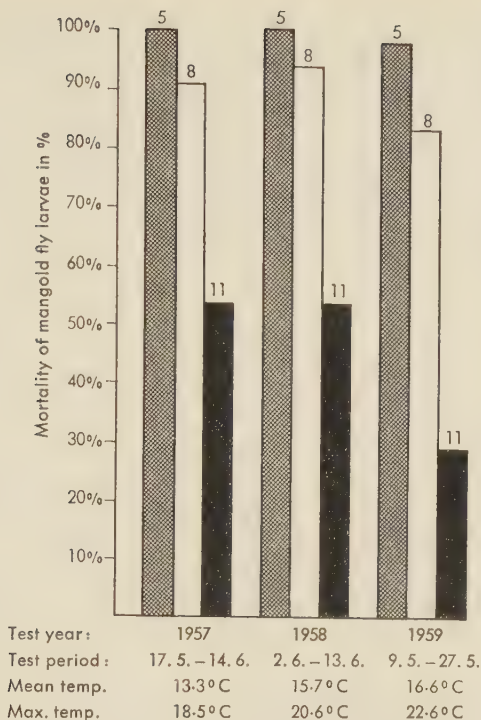


Fig. 3: Residual action of DIPTEREX against mangold fly (% mortality of larvae) in 1957, 1958 and 1959, 5, 8 and 11 days after spraying. The heavy infestation density that began at high temperatures in 1959 brought about a shorter residual action than in preceding years

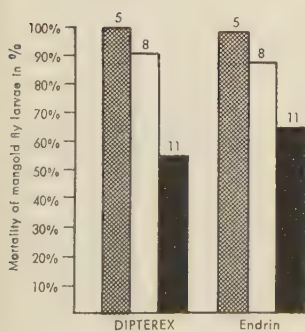


Fig. 4a: Average residual action of DIPTEREX and endrin against mangold fly in 1957. Mortality of larvae evaluated 5, 8 and 11 days after spraying (15)

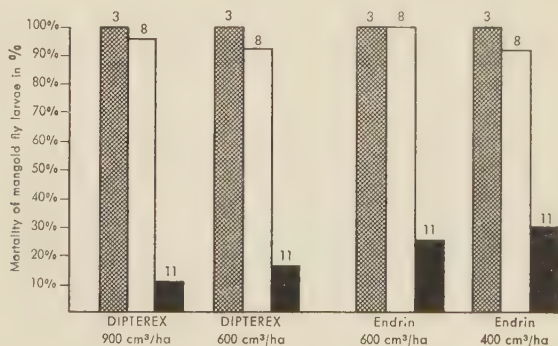


Fig. 4b: Shortened residual action of DIPTEREX and endrin against mangold fly in 1957 due to high temperatures, irrespective of rate of application. Mortality of larvae evaluated 3, 8 and 11 days after spraying (15)

on the averages for the 1957 tests, the residual action times registered for the test plotted in Fig. 4b — this test was carried out in a temperature peak period in 1957 — are similar to those recorded in 1959 also at unusually high temperatures (Fig. 3). A comparison of the maximum and mean temperatures recorded in the test periods of 1957, 1958 and 1959 furthermore reveals that in 1959 the residual action was shortened by constant high temperatures whereas the 1957 test plotted in Fig. 4b ran into a temperature peak period (maximum temperatures of up to 26.3 °C) from the 6th to the 11th day after the spray application, which also resulted in a shortening of the residual action. This is evident from the following table:

Test year	Dates of test	Max. temps. °C (given no. of days after spraying)				Mean temps. °C (given no. of days after spraying)			
		2 days	5 days	8 days	11 days	2 days	5 days	8 days	11 days
1957	18.5.—29.5.	19.1	13.8	14.2	14.1	14.3	9.9	10.4	9.0
1957	20.5.— 5.6.	14.7	15.9	20.3	23.8	9.9	10.4	13.8	16.9
1958	2.6.—13.6.	24.6	19.5	20.6	17.7	19.0	14.9	16.3	12.8
1959	9.5.—27.5.	22.8	21.8	21.1	21.8	16.3	16.9	15.5	16.2

The duration of the residual action of the different products is thus influenced not only by the density and persistence of infestation but also largely by the prevailing temperature conditions.

When we again briefly tabulate the data so far discussed regarding the initial and residual action of the products, then we arrive at the following relations, according to Fig. 1 and Fig. 3, between initial effect and residual action in respect of DIPTEREX which was tested over a period of 3 years.

Product	Test year	Initial effect (> 95 % larval mortality after given no. of hrs.)	Residual action (< 50 % larval mortality after given no. of dys.)
DIPTEREX	1957	< 24 hrs.	11—12 dys.
DIPTEREX	1958	< 24 hrs.	11—12 dys.
DIPTEREX	1959	< 24 hrs.	9—10 dys.

When the relations between initial and residual action, established for the different products in the 1958 and 1959 tests, are tabulated in the same form according to the values in Fig. 1, Fig. 2 and Table 7, the following survey is obtained:

Product	Test year	Initial effect (> 95 % larval mortality after given no. of hrs.)	Residual action (< 50 % larval mortality after given no. of dys.)
Organophosphorus compounds			
DIPTEREX	1958 + 1959	< 24 hrs.	10—11 dys.
LEBAYCID	1958 + 1959	< 24 hrs.	9—10 dys.
CHLORTHION	1958	24 hrs.	7— 8 dys.
DICONTAL	1958	< 24 hrs.	11—12 dys.
GUSATHION A	1959	< 24 hrs.	7— 8 dys.
Systemic insecticides			
* METASYSTOX	1959	∞	< 5 dys.
* METASYSTOX (i)	1958 + 1959	∞	< 5 dys.
* METASYSTOX R	1959	∞	8— 9 dys.
* Thiometon	1958 + 1959	∞	< 5 dys.
Chlorinated hydrocarbons			
* Lindane + dichlorodiphenyl- trichloroethane + dieldrin	1958	∞	11—12 dys.
* Hexachlorobicyclo- 2-heptene-5,6-bis- oxymethylenesulphite	1958 + 1959	∞	10—11 dys.
Carbamates			
* N-methyl-1- naphthylcarbamate	1959	∞	< 5 dys.
Combinations			
METASYSTOX (i) + DIPTEREX	1958 + 1959	24 hrs.	10—11 dys.

* According to Table 7, < 75 % mortality of larvae on all evaluation dates.

A rapid initial toxicity and a long residual action are accordingly established only for a few products such as DIPTEREX and LEBAYCID. Neither the initial effect nor the residual action is satisfactory among the systemic insecticides even though these products can be expected to bring about a certain reduction of infestation. Combinations of METASYSTOX (i) and DIPTEREX, containing low percentages of DIPTEREX, gave a satisfactory initial effect and residual action, just as in the 1957 tests.

Effect against aphid species

The following products were primarily tested in the aphid control trials (results of these tests are given in Tables 8, 9 and 10):

Organophosphorus compounds

LEBAYCID	}	systemic insecticides
METASYSTOX		
METASYSTOX (i)		
METASYSTOX R		

Other products

N-methyl-1-naphthylcarbamate
Fluoroacetamide

The aphid control trials were carried out against *Myzodes persicae* and *Aphis* (D) *fabae* on beets (Test 8), and against *Myzodes persicae* and *Macrosiphon solani* on potatoes (Tests 7 and 9). It will be noticed from the results given in Tables 8 to 10 that the initial infestation in the 1959 tests was very severe, the rate being 300 *M. persicae* per plant and 2000 *A. fabae* per plant for beets so that a sound basis was provided for assessing the initial action of the products. It is also evident from Tables 8 and 9 that both the systemic insecticides and LEBAYCID — we were especially interested in the action of the latter — gave a 100 % initial effect at all tested concentrations.

Besides the initial toxicity, we were particularly interested also in establishing the persistence of the products. As the rate of initial infestation, the density of infestation in the check plots and the percentage of winged aphids were very high during the whole of the test period both for *M. persicae* and *A. fabae*, it was possible to observe the residual action very closely. The residual action given against *A. fabae* was taken to have terminated when > 10 *A. fabae* were counted per beet plant, and for *M. persicae* when > 1 peach-potato aphid was observed on each beet plant or potato pinna.

The infestation figures were not converted into efficacy values because the differences between the products in the calculation of efficacy are completely obliterated due to the high infestation figures in the untreated check plots. An infestation rate of 0.5 to 1 *M. persicae* per beet plant, which when observed in regions of yellows infection results in a warning being issued to carry out aphid controls, would mean that an efficacy of 100 % is obtained when the infestation figures are converted to efficacy values (according to Abbott or Henderson and Tilton), making allowance for the high infestation rate in the check plot, thus not correctly reflecting the actual situation.

Taking into consideration the individual results given in Tables 8, 9 and 10, which the different products attained in respect of residual action, the persistence determined for the various products against *A. fabae* on beets and against *M. persicae* on beets and potatoes has been plotted in Fig. 5 to give a clearer picture. It is seen from this graph that the systemic insecticides METASYSTOX, METASYSTOX (i) and METASYSTOX R have the best residual action followed by LEBAYCID with a somewhat shorter persistence, whereas N-methyl-1-naphthylcarbamate and fluoroacetamide have a brief residual action and in fact do not even give a satisfactory initial effect.

The persistence of LEBAYCID is prolonged as the dosages are raised; this also applies to METASYSTOX (i) and METASYSTOX R, as shown by the results in Tables 8 and 9. At all events, LEBAYCID, applied at the high dosage

Table: 8 Test No. 8 (Buisdorf, Siegburg district)

Aphicidal effect of LEBAYCID (at various dosages) in comparison with systemic insecticides (against *Myzodes persicae* and *Aphis* [D.] *fabae* on sugar beets)

Date of spraying: June 5, 1959	Dosage ccs/ha	No. of aphids/beet plant given no. of days after spraying					
		Initial infesta- tion	3 days	6 days	8 days	11 days	14 days
<i>Myzodes persicae</i>							
METASYSTOX	800	458	0	1	0.2	6	3
METASYSTOX (i)	800	265	0.1	0	0.3	2	4
METASYSTOX (i)	400	167	0	0.1	0.5	8	3
METASYSTOX R	800	271	0	0	0	2	4
METASYSTOX R	400	230	0.3	0.5	0.1	1	4
LEBAYCID-Emulsion	800	222	0.5	0	15	10	13
LEBAYCID-Emulsion	1600	315	0	0	1.6	3	11
N-methyl-1-naphthylcarbamate	1600 g	405	28	14	62	224	192
Fluoroacetamide	1320	488	15	8	71	45	31
LEBAYCID-Emulsion	400	218	1.3	0.6	77	90	39
LEBAYCID-Emulsion	600	250	1	0.8	15	23	26
LEBAYCID-Emulsion	800	203	0.25	0.3	2	9	13
Untreated check	—	347	180	197	434	1307	2045
<i>Aphis</i> (D.) <i>fabae</i>							
METASYSTOX	800	625	0.3	1.3	2	14	23
METASYSTOX (i)	800	1308	0.2	0.6	2.2	7	11
METASYSTOX (i)	400	1530	1.6	3	1	26	12
METASYSTOX R	800	1848	0.2	0.3	0.5	8	14
METASYSTOX R	400	2620	0.5	0.8	1.4	12	14
LEBAYCID-Emulsion	800	1965	0.2	2.7	21	55	37
LEBAYCID-Emulsion	1600	2858	0.7	1.2	13	24	50
N-methyl-1-naphthylcarbamate	1600 g	473	7	46	57	242	172
Fluoroacetamide	1320	1193	4.1	13	20	57	51
LEBAYCID-Emulsion	400	115	6.3	2.5	54	71	48
LEBAYCID-Emulsion	600	230	0.4	4.5	33	41	58
LEBAYCID-Emulsion	800	628	0.25	3	15	19	56
Untreated check	—	2635	1285	2680	2743	2189	4058

Table 9: Test No. 9 (Kurtkottenhof Leverkusen)

Aphicidal effect of LEBAYCID in comparison with systemic insecticides (against *Myzodes persicae* and *Macrosiphon solani* on potatoes)

Date of spraying: June 4, 1959	Dosage ccs/ha	No. of aphids on 10 pinnae given no. of days after spraying								
		Initial infesta- tion	1 day	2 days	4 days	6 days	8 days	10 days	12 days	16 days
METASYSTOX	800	444	0	0	1	0	4	7	52	125
METASYSTOX (i)	800	243	0	0	0	0	6	17	16	136
METASYSTOX (i)	400	602	4	0	0	0	14	67	26	149
METASYSTOX R	800	478	0	0	0	3	0	33	46	113
METASYSTOX R	400	364	9	0	24	79	95	141	71	122
LEBAYCID-Emulsion	800	544	0	0	3	64	42	158	232	341
LEBAYCID-Emulsion	1600	415	0	0	0	4	4	48	134	312
N-methyl-1-naphthyl- carbamate	1600 g	483	536	485	1542	1462	1994	3271	6530	9540
Fluoroacetamide	1320	484	359	261	1266	1292	3798	4302	5220	4596
Untreated check	—	524	1153	1141	1201	2175	1897	5412	7925	7860

Table 10: Test Nr. 7 (Kurtkottenhof/Leverkusen)

Aphicidal effect of LEBAYCID against *Myzodes persicae* and *Macrosiphon solani* on potatoes

Date of spraying: July 17, 1958	Dosage ccs/ha	Initial infesta- tion	No. of aphids on 10 shoots given no. of days after spraying					
			1 day	2 days	4 days	6 days	8 days	11 days
LEBAYCID-Emulsion	500	57	0	2	26	19	11	4
4891a	600	69	2	2	28	12	9	3
METASYSTOX (i)	800	75	0	0	0	0	0	1
4859	600	125	0	0	2	3	9	8
4892	600	71	12	64	99	86	62	52
LEBAYCID-Emulsion	800	52	1	0	1	0	2	2
Untreated check	—	76	236	74	51	42	35	48

levels, has — in comparison with the systemic insecticides — a most appreciable residual action against *A. fabae* and especially against *M. persicae*, this in addition to the good effect against mangold fly which we have already mentioned.

It should also be pointed out once again that the 1959 trials were carried out in a period of heavy infestation density, thus providing stringent test conditions.

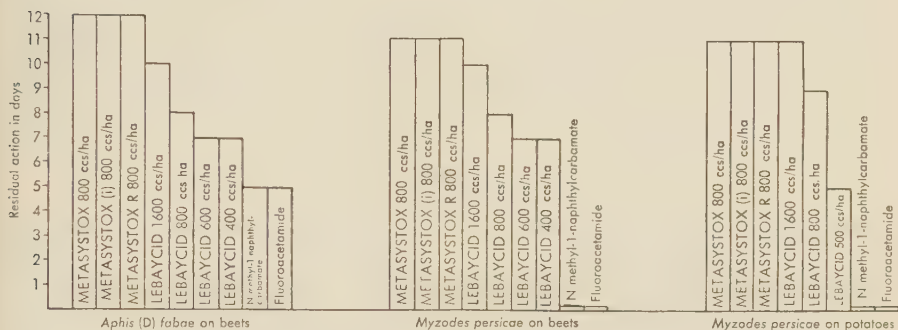


Fig. 5: Residual action of systemic insecticides compared with LEBAYCID against *Aphis (D.) fabae* on beets and *M. persicae* on beets and potatoes (see Tables 8 to 10 for individual values)

Simultaneous effect against mangold fly and aphid species

The tests we carried out also aimed at establishing whether LEBAYCID is a suitable product for simultaneously controlling mangold fly and aphid species, and whether the residual action of LEBAYCID, compared with DIPTEREX against mangold fly, and with systemic insecticides, such as METASYSTOX (i), against aphid species, is sufficient to suppress both pests. In other words, we had to ascertain whether LEBAYCID, by virtue of its wider spectrum of activity, can be used as a replacement for the products respectively active against only 1 of the 2 pest species, in the event of a simultaneous infestation of mangold fly and aphid species.

A product used for controlling mangold fly and aphids in a joint operation must be required to combine the properties of the different preparations normally applied separately against these pests, namely the efficacy of such products as DIPTEREX against mangold fly, and that of systemic insecticides such as METASYSTOX (i) against aphid species. Combinations of METASYSTOX (i) and DIPTEREX are used with a good measure of success for simultaneously controlling both pests, thus satisfying these requirements, which is especially important in regions of yellows infection where a product simultaneously effective against mangold fly and aphids must have a high standard of aphicidal action.

Fig. 6 provides, as viewed from this aspect, a comparison of the initial toxicity and residual action values obtained in our tests against mangold fly and aphids, with METASYSTOX (i), DIPTEREX, LEBAYCID and a combination of METASYSTOX (i) and DIPTEREX. Whereas METASYSTOX (i), apart from giving its usual excellent control of aphids, is only slightly effective against mangold fly, while DIPTEREX, on the other hand, is very effective against mangold fly but gives inadequate control of aphids, LEBAYCID not only produces a very good initial effect against mangold fly and aphids but also possesses a most outstanding residual action against both pests, using a concentration

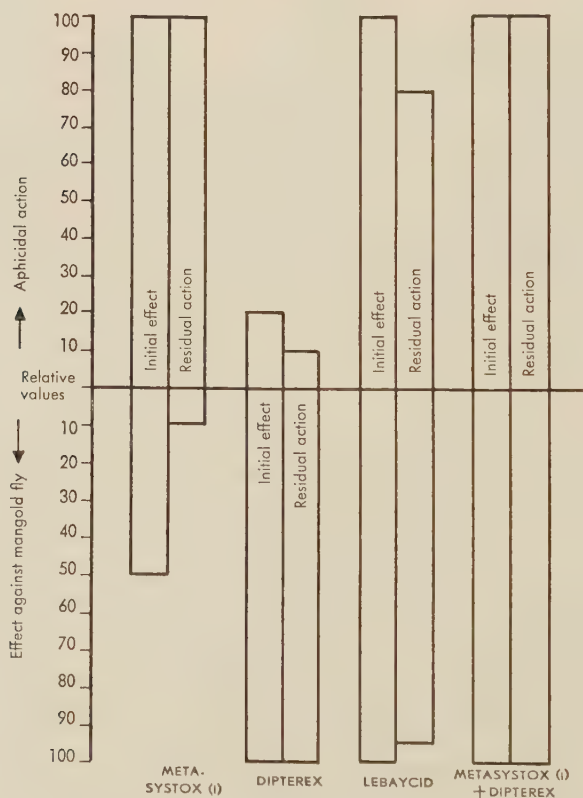


Fig. 6: Initial toxicity and residual action of LEBAYCID against mangold fly and aphid species, in comparison with METASYSTOX (i), DIPTEREX and a combination of METASYSTOX (i) + DIPTEREX*

* In order to make the illustration clearer, the values obtained with DIPTEREX against mangold fly and with METASYSTOX (i) against aphids have been plotted to equal 100, and the results of the other products are plotted in relation to DIPTEREX for their effect against mangold fly, and in relation to METASYSTOX (i) for their aphidical action

which, in view of the residual effect, has been fixed at 0.15 %, in other words a dosage of 900 ccs/ha based on a volume of 600 litres of spray solution per hectare. In the event of infestation being slight — so that the residual action does not have to satisfy a high standard — and when mangold fly is in the majority, the concentration can be lowered, and vice-versa it can be raised when infestation is severe and aphids are in greater abundance.

From observations so far made, it can thus be stated that LEBAYCID is suitable for simultaneously controlling mangold fly and aphid species, and due to its persistence against aphids it can also be used in regions of less severe yellows infection for combined controls of vectors and mangold fly larvae. Therefore, LEBAYCID should provide an effective replacement for the combinations of mangold fly control products and aphicides that are used in many cases (for example, METASYSTOX [i] and DIPTEREX).

Summary

The mangold fly and the aphid species *Aphis* (D.) *fabae* and *Myzodes persicae* are major epidemic pests of beets, and their control must be given special attention. Whereas *M. persicae* as the most important carrier of virus yellows is restricted to certain climatic regions for its epidemic mass reproduction, mangold fly and *A. fabae* can occur everywhere in the Federal Republic on an epidemic scale and often unexpectedly, facts which make it necessary to have a well-practised control technique. The problem of controlling aphid species has been largely solved by the use of systemic insecticides such as METASYSTOX (i), which have a long residual action, likewise the control of mangold fly which is achieved with DIPTEREX or other organophosphorus compounds and chlorinated hydrocarbons. The situation is difficult to master when mangold fly and aphid species occur at the same time, and thus have to be controlled in a combined operation, which is frequently the case; the difficulty arises out of the fact that the systemic insecticides used for controlling aphids have only a weak action against mangold fly, while the mangold fly control products do not act against the aphid species. Therefore, the practice has been adopted in recent years of applying the respective mangold fly control products and aphicides in combined sprays to suppress simultaneous outbreak of mangold fly and aphid infestation. Combinations frequently used in such cases, with a good residual action against both pests, were 600—800 ccs/ha METASYSTOX (i) plus 300 ccs/ha DIPTEREX Emulsion.

In field trials carried out in 1958 and 1959 (a year of severe mangold fly and aphid infestation), LEBAYCID, a new organophosphorus compound with a low order of mammalian toxicity, was found to possess a good residual action against mangold fly and the aphid species of *M. persicae* and *A. fabae*.

The trials aimed at accurately testing the residual action of LEBAYCID in comparison with the conventional products. Therefore, in the mangold fly controls trials, LEBAYCID was compared with other organophosphorus compounds (DIPTEREX, CHLORTHION, DICONTAL, GUSATHION A), with systemic insecticides (METASYSTOX, METASYSTOX (i), METASYSTOX R, Thiometon) — we were also interested in establishing their action against mangold

fly — as well as with chlorinated hydrocarbons and carbamates. In the aphid control tests, LEBAYCID was primarily compared with the systemic insecticides.

LEBAYCID, like DIPTEREX, has a very good initial action against mangold fly larvae; the 2 products differ only very slightly in their residual action.

All the systemic insecticides, in contrast to the other tested organophosphorus compounds, have an unsatisfactory initial toxicity and residual action against mangold fly, and therefore bring about only a slight reduction of infestation. Results so far obtained show that METASYSTOX R gives somewhat better control of mangold fly than the other systemic insecticides.

As illustrated by a comparison of the persistence values registered for DIPTEREX against mangold fly larvae in 1957, 1958 and 1959, the residual action becomes shorter at high temperatures, and can only be slightly prolonged by raising the concentration or dosage. In 1957 (severe infestation) and 1958 (moderate infestation), DIPTEREX was persistent* for 11 to 12 days, but in 1959 (severe infestation) its residual action lasted only 9 to 10 days. Similar results were obtained also for LEBAYCID, endrin and other products.

LEBAYCID, just like the systemic insecticides, has a very good initial action against the aphid species of *M. persicae* and *A. fabae*; the initial infestation in the tests was 300 *M. persicae* per plant and 2000 *A. fabae* per plant. The residual action of LEBAYCID is somewhat shorter than that of the systemic insecticides but just as for the latter (METASYSTOX, METASYSTOX [i], METASYSTOX R) it can be prolonged by raising the dosages. From observations so far made, LEBAYCID can, therefore, be used in the event of simultaneous occurrence of mangold fly and aphid species, also in regions of less severe yellows infection for combined controls of vectors and mangold fly larvae, in place of the hitherto usual combinations of METASYSTOX (i) + DIPTEREX.

In view of the residual action so essential for simultaneous control of mangold fly and aphid species, a concentration of 0.15 %** (900 ccs/ha) is recommended for LEBAYCID. In the event of slight infestation and a greater abundance of mangold fly, the concentration can be lowered, whereas it can be raised when infestation is severe and aphids are in the majority.

References

1. Blaesen, P., and Thielemann, R.:

Zur Frage der Bekämpfung der Vergilbungskrankheit der Beta-Rüben durch Überträgerbekämpfung mit chemischen Mitteln. II. Die Wirkung verschiedener Wirkstoffgruppen auf die Blattlauspopulation der Beta-Rüben. — Zeitschr. f. Pflanzenkrankh. u. Pflanzenschutz 65 (3), 129—143, 1958.

2. Blaszyk, P.:

Wirtschaftliche Erfolge bei der Blattlausbekämpfung im Samenrübenaubau im ostfriesischen Raum. — Nachrichtenblatt des Deutschen Pflanzenschutzdienstes 12 (1), 15, 1960.

3. Börner, C., and Heinze, K.:

Blattläuse. — Handb. der Pflanzenkrankh. 5 (2), 107—113, 189—199, 243—246, 1957.

* End of residual action when < 50 % larval mortality is established

** Based on a volume of 600 litres spray solution/ha

4. Börner, C., and Janisch, R.:
Zur Lebensgeschichte und Bekämpfung der „Schwarzen Blattläuse“. —
Nachrichtenblatt für den Deutschen Pflanzenschutzdienst 2 (8), 65—67, 1922.
5. Börner, C., and Schilder, F. A.:
Blattläuse. — Handbuch der Pflanzenkrankheiten 5 (2), 565—566, 598—602,
617—618, 1932.
6. Bremer, H.:
Beitrag zur Epidemiologie der Rübenfliegenkalamität. — Arbeiten aus der
Biol. Reichsanstalt 17, 104—193, 1929.
7. Bremer, H., and Stapel, C.:
Zur Temperaturabhängigkeit der Rübenfliegen-Epidemien. — Zeitschr. f.
Pflanzenkrankheiten und Pflanzenschutz 66 (10), 636—640, 1959.
8. Dunning, R. A.:
Mangold fly attacks in 1955. — Use of Metasystox in their control. — Brit.
Sug. Beet Rev. 24 (3), 121—124, 127—128, 1956.
- 8a. Gersdorf, E.:
Weitere Untersuchungen an Puppentönnchen der Rübenfliege. — Zucker 13
(4), 99, 1960.
9. Hull, R.:
Sugar beet yellows in Great Britain, 1958. — Plant Pathology 8 (4), 145, 1959.
10. Janisch, R.:
Lebensweise und Systematik der „Schwarzen Blattläuse“. — Arb. Biol.
Reichsanstalt 14, 291—366, 1926.
11. Jones, F. G., and Dunning, R. A.:
The control of mangold fly (*Pegomya betae* Curtis) with DDT and other
chlorinated hydrocarbons. — Ann. appl. Biol. 46, 132—154, 1954.
12. Kennedy, J. S.:
Benefits to aphids from feeding on galled and virus-infected leaves. —
Nature 168, 825, 1951.
13. Kennedy, J. S. & Booth, C. O.:
Host alternation in *Aphis fabae* Scop. I. Feeding preferences and fecun-
dity in relation to the age and kind of leaves. — Ann. appl. Biol. 38,
25—64, 1951.
14. Kersting, F.:
Erfahrungen zur Rübenfliegenbekämpfung. — Gesunde Pflanzen 9 (4),
68—71, 1957.
15. Kolbe, W.:
Untersuchungen über die Bekämpfung der Rübenfliege. — Höfchen-Briefe,
11 (2), 37—70, 1958.
16. Koltermann, A.:
Lehren aus den Rübenfliegenjahren 1956 und 1957. — Mitteilungen der DLG
73 (4), 78—79, 1958.
17. Missonnier, J.:
Essais de lutte contre la mouche de la betterave. — Annales des Epiphy-
ties 1, 19—36, 1959.

18. Molz, E.:
Blattlausbekämpfung mittels des „Landaurets“. — Zeitschr. f. Pflanzenkrankheiten 27, 107—110, 1917.
- 18a. Mühlmann, R., and Schrader, G.:
Hydrolyse der insektiziden Phosphorsäureester. — Zeitschr. f. Naturforschung 12 (3), 196—209, 1957.
19. Rump, L., and Niemöller, A.:
Vorarbeiten zu einer Voraussage über das Auftreten der Rübenfliege im Jahre 1958, durchgeführt in der Zeit vom 17. 10. bis 26. 10. 1957. — Höfchen-Briefe 11 (1), 1—14, 1958.
20. Schrader, G.:
Die Entwicklung des Bayer-Präparates S 1752. — Höfchen-Briefe 13 (1), 1—13, 1960.
21. Steudel, W.:
Zur Frage der Bekämpfung der Vergilbungskrankheit der Beta-Rüben durch Überträgerabtötung mit chemischen Mitteln. I. Die Wirkung des Präparates „Systox“ auf die Blutlauspopulation der Beta-Rüben. — Zeitschr. f. Pflanzenkrankheiten und Pflanzenschutz 59, 418—430, 1952.
22. Steudel, W.:
New problems associated with systemic treatment of sugar beets. Institut International de Recherches Betteravières. — Report 21st Winter Congress, 229—234, 1958 (Brussels).
23. Steudel, W., and Blaesen, P.:
Zur Frage der Höhe der Blattlaussaugschäden im Seuchengebiet der Vergilbungskrankheit (Beta-Virus 4). — Zucker 10, 428—432 and 445—448, 1957.
24. Steudel, W., and Blaesen, P.:
Bericht über die in den Jahren 1955 und 1956 durchgeführten Gemeinschaftsuntersuchungen zum Auf- bzw. Ausbau eines Blattlauswarndienstes im Rübenbau. — Mitt. Biol. Bundesanstalt 92, 37 pag., 1958.
25. Steudel, W., and Heiling, A.:
Die Vergilbungskrankheit der Rübe. — Mitt. Biol. Zentralanstalt 79, 132 pag., 1954.
26. Steudel, W., Heiling, A., and Hanf, E.:
Versuche zur inneren Therapie bei Beta-Rüben durch Saatgutbehandlung mit systemischen Präparaten. — Zeitschr. angew. Entomologie 44, 387—404, 1959.
27. Unterstenhöfer, G.:
Die Bekämpfung von Pflanzenschädlingen durch Saatgutbehandlung mit systemischen Insektiziden. — Zeitschr. f. Pflanzenkrankheiten und Pflanzenschutz 64, 619—625, 1957.
28. Unterstenhöfer, G.:
LEBAYCID, ein neues mintertoxisches Insektizid. — Höfchen-Briefe 13 (1), 44—52, 1960.
29. Winner, C.:
Nur gesunde Rüben bringen höchste Erträge. — Mitteilungen der DLG 73 (8), 194—195, 1958.
30. Jahresberichte der Pflanzenschutzämter 1956 und 1957. Herausgegeben von der Biologischen Bundesanstalt, Braunschweig, 1958.

Experience on the use of FOLIDOL® Oil for treating pome fruit, especially against winter moth (*Cheimatobia brumata* L.)

by Karlheinz K ü t h e , Crop Protection Office, Frankfurt/Main (Giessen branch).

In the area administered by the Giessen Crop Protection Branch Office, which includes parts of Vogelsberg in one direction, and parts of the Taunus, Rothaargebirge and Westerwald (middle section of the Lahntal from Biedenkopf to almost as far as Limburg) in the other direction, orchardists are still recommended to carry out winter spraying of their crops.

Experience has shown that every year, besides the injuries inflicted on the fruit trees by sucking pests such as aphids, apple suckers and scale insects, considerable damage, sometimes resulting in skeletonizing, is caused in part of the area by winter moth or ermine moth. Substitution of winter spraying by a pre-blossom spray application has repeatedly led to setbacks involving appreciable financial losses, for the sucking pests start their attacks, and in fact the caterpillars also begin to feed on the trees, before pre-blossom spraying is carried out.

For the crop protection technicians who supervise and carry out spraying operations in the greater part of the area, the corrosive action and the staining of the usual types of winter sprays are very unpleasant secondary effects, as are also the more or less severe burns on interplanted crops, especially in orchards. Therefore, it has been the practice for several years past to subject newly marketed winter sprays to special testing from the above-mentioned aspects. FOLIDOL Oil was also tested at various places, after it had been approved by the German Federal Biological Institute. Information supplied on this product stated that it was expected to give effective control of numerous pests. We were especially interested in its effect against winter moth, for observations carried out in autumn, 1958 indicated that there would be a severe occurrence of this pest in spring, 1959. Another point of major interest to us was to establish what influence timing of the spray application would have on the percentage of mortality.

Reports from crop protection technicians have meanwhile revealed that in some places FOLIDOL Oil was used on a very large scale. All workers were unanimous in stating that they would use it again in the coming year. No burns were caused on interplanted crops and in fact no injuries to earthworms were observed such as had been repeatedly caused by other products in previous years.

Detailed observations were carried out at four places on the effect given against pests on apple trees, especially against winter moth infestation.

1. Bicken (Dillkreis)	300 metres a. s. l.
2. Frohnhausen (Dillkreis)	375 metres a. s. l.
3. Weyer (Kreis Oberlahn)	200 metres a. s. l.
4. Mornshausen (Kreis Biedenkopf)	280 metres a. s. l.

We were assisted in arranging and evaluating the tests by the competent district crop protection consultants to whom we would express our thanks for their cooperation. At all four test sites, FOLIDOL Oil was sprayed at 0.5 % in comparison with untreated trees and trees treated with DNOC (SELINON®) at 1 %.

1. Test at Bicken (Dillkreis)

The test site at Bicken is a 20 year-old community orchard located on a slope, and surrounded by wood on three sides. The treatment was carried out on April 7, and the test was evaluated on May 6, 1959 for winter moth, bud moth and apple sucker infestation. Each plot included 5 trees. At the evaluation on May 6 and 13, four samples each containing 25 buds were taken per tree, so that 20 samples containing a total of 500 buds were evaluated per treatment. In the lower part of the orchard, on the Boskoop variety, the average infestation for untreated was 90 caterpillars on 100 buds, whereas in the upper part of the orchard, on the Landsberger and Croncels varieties, infestation was as high as 165 caterpillars per 100 buds. This infestation led to complete skeletonization.

FOLIDOL Oil was applied on April 7 by means of an atomizer at five times the normal dosage (2.5 %), and at a volume of 1.4 litres of spray solution per tree. The winter moth larvae started to hatch out on the day of this treatment. A spray application of dichlorodiphenyltrichloroethane/lindane was carried out on April 15 when the winter moth caterpillars were already in the buds. Infestation was evaluated on May 6 and 13, and feeding damage on May 19.

In this test, FOLIDOL Oil was very effective against the observed pests. The number of winter moth caterpillars was reduced to an average of 10 per 100 buds (see Table 1), whereas following the dichlorodiphenyltrichloroethane/lindane application infestation was reduced to only 45 caterpillars per 100 buds. The foliage of the treated trees was saved; on the untreated trees, however, the foliage was skeletonized.

Bud moth infestation was also reduced:

14 on untreated

2 on trees treated with FOLIDOL Oil

The figures for apple sucker infestation were:

293 for untreated

0 for FOLIDOL Oil

Evaluation rating for Tables 1 to 4:

Caterpillar infestation or feeding damage on buds or leaf clusters.

1 = no infestation or no feeding damage

2 = 1— 25 %

3 = 26— 50 %

4 = 51— 75 %

5 = 76—100 %

} infested leaf clusters or damaged
by feeding

Table 1:

Plot	No. of trees	No. of samples	Percent infestation of winter moth caterpillars on examined samples					Average no. of caterpillars on 100 buds	Average feeding damage evaluat. on May 19/20	
			1	2	3	4	5			
a) Test at Bicken										
Evaluation on May 6, 1959										
Untreated 1	5	20	—	—	5	25	70	91		
Untreated 2	6	24	—	—	—	—	100	165	5.0	
FOLIDOL Oil April 7, 59	5	20	25	60	15	—	—	10		
Dichloro- diphenyl- trichloroethane/ lindane April 15, 59	3	12	—	17	50	33	—	43	2.75	
b) Test at Frohnhausen										
Evaluation on May 8, 1958										
Untreated	5	20	—	—	20	30	50	70	3.9	
FOLIDOL Oil Feb. 17, 59	6	24	—	96	4	—	—	16	2.7	
March 17	6	24	—	25	71	4	—	33	2.6	
April 10	6	24	—	100	—	—	—	18	2.3	
SELINON Feb. 17	6	24	—	75	25	—	—	21	2.5	
Trap banding										
	6	24	—	25	54	21	—	39	3.5	

2. Test at Frohnhausen (Dillkreis)

A 27 year-old community orchard, likewise bordered by woodland, was also used for the test at Frohnhausen. In Bicken, other products and questions were studied, whereas the prime object of the Frohnhausen trial was to assess the timing of FOLIDOL Oil spray applications, carried out on different dates, in comparison with DNOC. Winter moth infestation was, however, less severe than in Bicken; the average rate was recorded at 70 caterpillars per 100 buds. Accordingly, the feeding damage on untreated trees was also less. Besides this trial, another test was also carried out near to in autumn, 1958, in which sticky bands were applied to 10 apple trees. The total length of banding amounted to 7 metres, and a count on Nov. 27, 1958 showed a population of 834 females, in other words about 120 females per metre. Nevertheless, there was still a marked caterpillar infestation on the trees in spring, 1959, on the average 39 caterpillars per 100 buds. The effect of winter spraying was much better than that given by sticky bands. Winter spraying reduced infestation to a rate of 16 caterpillars per 100 buds, resulting also in less feeding damage.

The spray solution was applied by means of an orchard motor sprayer, at an average volume of 8 litres per tree.

The 1st spray application was carried out on Feb. 17, using 1 % DNOC and 0.5 % FOLIDOL Oil. Surprisingly, FOLIDOL Oil was at this early stage of the year even more effective than DNOC.

The 2nd spray application of FOLIDOL Oil was on March 17 when its effect proved to be somewhat less successful than on Feb. 17, 1959.

The 3rd spray application took place on April 10, being more effective than the second treatment.

The tests were evaluated in the same manner as at Bicken.

There were 6 trees in each plot, so that 600 buds were evaluated for each group. In this case, all the spray applications were more effective than just trap banding.

In addition, there is the effect given by the sprays against other pests such as apple sucker and bud moth. When the results of the three FOLIDOL Oil sprays are combined and compared with DNOC, the effect is found to be about the same.

The first caterpillars were observed on April 10. The evaluation of winter moth infestation was carried out from April 30 to May 8, 1959, and of feeding damage on May 20, 1959 (Table 1).

3. Test at Weyer (Kreis Oberlahn)

Weyer borders on the Limburg Basin: situated 200 metres a. s. l. it is much lower than test sites 1, 2 and also 4. The test at Weyer was carried out in two bush tree orchards, a) 3 years old and b) 5 years old: in the other tests, standard trees were used. Due to the small number of buds on the bush trees, it was not possible to examine the single buds for the evaluation of the test, and we had to be satisfied with an evaluation of the overall condition of the trees. In a), there were 60 trees in the untreated plot, the same number in the DNOC plot, and 20 in each of the FOLIDOL Oil plots: in b), there were on the average 20 trees each in the untreated, FOLIDOL Oil and dichlorodiphenyltrichloroethane/lindane plots.

Spraying schedule:

- | | |
|--|---------------------------|
| 1. DNOC 1 % | on Feb. 26, 1959 |
| 2. FOLIDOL Oil 0.5 % | on March 9, 1959 |
| 3. FOLIDOL Oil 0.5 % | on March 20, 1959 |
| 4. FOLIDOL Oil 0.5 % | on April 7, 1959 |
| 5. Dichlorodiphenyltrichloroethane-lindane | on April 13 and 29, 1959* |

The first occurrence of caterpillars was observed on April 7. Evaluation of feeding damage was carried out from May 12 to 15, 1959. Based on the experience gained in tests 1 and 2, feeding damage corresponds to the rate of caterpillar infestation. A spot check made on April 7 showed that 80 % of the buds were infested in the untreated plot, corresponding to an infestation rating of 5, i. e. at least 80 caterpillars per 100 buds. The effect of FOLIDOL Oil was most considerable also in these tests, being at least equal to that of DNOC, and in fact better when FOLIDOL was applied later.

* 10 trees were treated on April 13, and another 9 on April 29, 1959.

Table 2: Test at Weyer (Kreis Oberlahn). Evaluation on May 15, 1959

Plot	No. of trees	% feeding damage by winter moth caterpillars				
		1	2	3	4	5
a) untreated	60	—	—	5	33	62
FOLIDOL Oil						
9. 3. 59	30	—	—	17	37	46
20. 3.	20	—	—	25	45	30
7. 4.	20	—	15	60	25	—
SELINON						
26. 2.	60	—	2	23	53	22
b) untreated	22	—	—	14	41	45
FOLIDOL Oil						
7. 4. 59	20	—	45	50	5	—
dichlorodiphenyl- trichloroethane/ lindane						
13/29. 4.	19	—	58	37	5	—

DNOC was applied by means of orchard motor sprayers, and FOLIDOL Oil and dichlorodiphenyltrichloroethane/lindane with knapsack sprayers (Table 2).

4. Test at Mornshausen (Kreis Biedenkopf)

This test was also carried out in a community orchard situated near Mornshausen, and bordered on 2 sides by wood; the standards were about 20 years old. There were 5 trees in each test group, which were sprayed with a motor-powered knapsack atomizer at five times the normal concentration.

1. FOLIDOL Oil on Feb. 28, 1959
2. DNOC on March 5
3. FOLIDOL Oil on March 18
4. FOLIDOL Oil on April 6

The first caterpillars were observed on April 6. The evaluation of infestation by winter moth and other pests was carried out on May 2 on 2 trees in each test group. In the untreated plot, the count showed an infestation of 86 winter moth caterpillars and 502 sucker larvae per 100 buds. The various treatments brought the number of winter moth caterpillars down to a level of 2 to 14 per 100 buds, and the number of apple sucker larvae was reduced to between 8 and 42. Therefore, in all cases infestation was considerably decreased, the best result being given by the spray application of FOLIDOL Oil on March 18. These results were confirmed by the second evaluation of winter moth feeding damage on leaves, carried out on May 14; each tree was rated from 1 to 5 according to its general condition (1 = no feeding damage, 5 = skeletonized). See Table 3.

Table 3: Test at Mornshausen (Kreis Biedenkopf)

Plot	No. of trees	% infestation density					Infestation on 100 buds on June 2, 1959	
		1	2	3	4	5	winter moth	apple sucker
Untreated	5	—	—	—	30	70	86	502
DNOC 5.3.59	5	—	40	50	10	—	4	38
FOLIDOL Oil 28.2.59	5	—	10	80	10	—	14	42
18.3.	5	20	70	10	—	—	2	8
6.4.	5	—	20	60	20	—	8	18

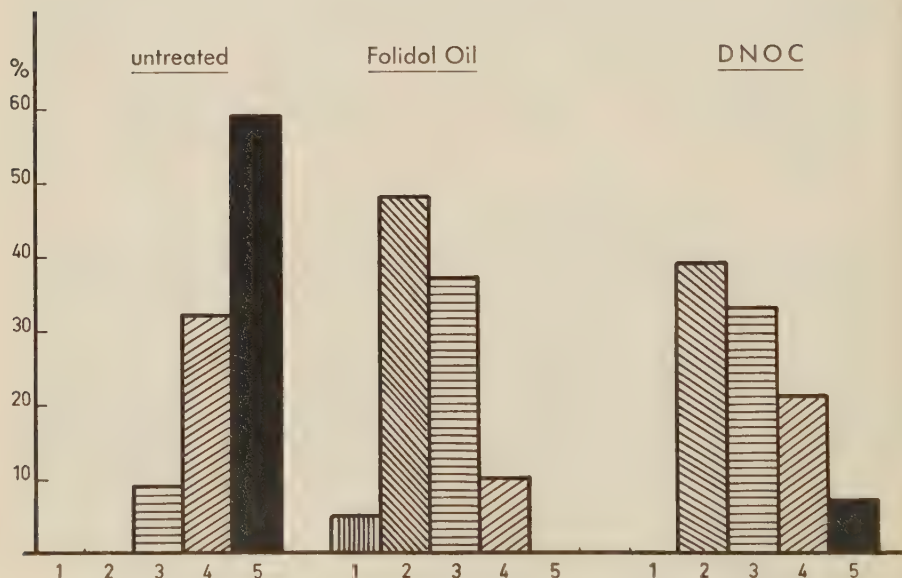


Fig. 1: Infestation and feeding damage by winter moth (*Cheimatobia brumata* L.) on untreated trees, and on trees treated with 0.5% FOLIDOL Oil early in April and with 1% DNOC at the end of February and early in March (combined results of 5 tests carried out in 1959).

Evaluation rating: 1 = free of infestation 4 = 51—75% infestation
 2 = 1—25% infestation 5 = 76—100% infestation
 3 = 26—50% infestation

Summary

On examining the results of the tests described in this paper, it is evident that FOLIDOL Oil can be effectively used against winter moth (*Cheimatobia brumata* L.) from February to early April — at the mouse-ear stage and emergence of winter moth caterpillars — and that the effect of FOLIDOL Oil

is not only equal to that of DNOC and a dichlorodiphenyltrichloroethane/lindane spray, but may even be better when the application is suitably timed. The information of Bender (1959) is confirmed, namely that isolated winter moth are still to be found on the treated trees at an evaluation in May.

The average results for the untreated plots (except test 1b) showed that there are 81 winter moth caterpillars (70—90) on 100 buds or leaf clusters, in other words practically every bud or every leaf cluster was infested. This led to skeletonizing in May on most untreated trees. A spray application reduced infestation to such an extent (see Tables 1 to 3 and Fig. 1) that the number of caterpillars dropped on the average to 14 per 100 leaf clusters, in the most favourable cases to 2, and in the most unfavourable to 33.

On combining all the results, there is no significant difference evident in the effect of FOLIDOL Oil when applied on different dates in February, March and April (see Table 4). The best result was obtained, despite the most severe

Table 4: Effect of DNOC and FOLIDOL Oil against winter moth infestation. Average values for 3 tests (Tables 1b, 2a and 3).

Plot	Infestation density in ‰					Winter moth infestation on 100 buds in May, 1959
	1	2	3	4	5	
Untreated	—	—	8	31	61	79
DNOC 1 ‰	—	39	33	21	7	12
FOLIDOL Oil						
1st spray	—	35	34	16	15	15
2nd spray	7	32	35	16	10	17
3rd spray	—	45	40	15	—	13

infestation on untreated, on March 18 in Mornshausen (Table 3) and on April 7, 1959 in Bicken (Table 1). The treatment on February 17 in Frohnhausen also gave a good effect (Table 1). At the time of the spray application early in April, the first caterpillars had already hatched out — except at Bicken — and some had entered the buds where they were practically safe from the spray. The resultant damage caused by these caterpillars could not be taken into account at the evaluations. In the opinion of the author, the best practice is to carry out spraying shortly before or during the hatching of winter moth caterpillars in order also to eliminate damage due to bud feeding which is undoubtedly caused. It could not be established why early spraying had a better effect at one site and late spraying was more effective at another place.

The very good effect of FOLIDOL Oil against apple suckers was confirmed in all tests. At Bicken, infestation (293 larvae per 100 buds on untreated trees) was reduced to 0 in the treated plot, whereas at Mornshausen it was reduced, in the most favourable case, from 502 to 8, and in the most unfavourable case to 42. A good effect was also produced against bud moth

in the test at Bicken (14 per 100 buds on untreated, and 2 per 100 buds on treated).

The very severe winter moth infestation registered in all the tests, was considerably reduced by applying DNOC, DDT/lindane or Folidol Oil spray, but it could not be completely eliminated by any of these products or, for that matter, by applying sticky bands. Observations made elsewhere have revealed that in such cases two sprayings — one before or during bud burst, and the second as a pre-blossom spray — are needed to guarantee prevention of feeding damage.

The good effect of a FOLIDOL Oil spray application is illustrated by the fact that in the untreated plot, 91 % of the leaf clusters were severely infested (rating of 4 to 5) and only 9 % were slightly infested (rating of 2 to 3), whereas the ratio was just the reverse following a well-timed FOLIDOL Oil spray, namely 10 % of the leaf clusters were severely infested and 90 % were only slightly or not at all infested (see Fig. 1).

FOLIDOL Oil can be applied with conventional type spraying equipment such as knapsack sprayers, orchard motor sprayers and motor-powered knapsack atomizers. No differences in effect were observed.

References

Bender, E.:

Zur Austriebsspritzung mit Folidol-Öl. Höfchen-Briefe 1959, 16—19.

Engel, H.:

Vorteile und Nachteile der Oleo-Phosphorsäureester-Präparate. Höfchen-Briefe 1958, 124—128.

Roesler, R.:

Erfahrungen mit Folidol-Öl-Spritzmittel bei der Bekämpfung der Großen Napschildlaus (*Eulecanium corni* Bche.) an Reben. Höfchen-Briefe 1958, 121—123.

v. Rosenberg:

Bericht über den Einsatz verschiedener Insektizide zur ersten Vorblütespritzung und die Verwendung von Oleo-Phosphorsäureester zur zweiten Vorblütespritzung 1958. Höfchen-Briefe 1959, 20—21.

Sebbel, H.:

Die Bedeutung der Winterspritzung und der Einsatz von Folidol-Öl. Höfchen-Briefe 1958, 129—131.

Wildbolz, Th.:

Versuche mit den Oleo-Phosphorsäureester-Präparaten im Jahre 1956. Schw. Z. für Obst- u. Weinb. 1957, 25—33.

Tests on the Control of Apple Fruit Moth (*Argyresthia conjugella* Zell.)**

by K. Kr ä m e r

The natural host of the apple fruit moth (*Argyresthia conjugella* Zell.) is mountain ash, and the caterpillars feed on the developing fruits. It has, however, long been known as a pest of apple, as its common name implies. The larvae tunnel into the fruit imparting it with a bitter taste; once attacked, the fruits are unfit for use (Fig. 1). For many years past, apple fruit moth has regularly occurred in such great abundance in the orchards of certain areas in Hesse that it has been necessary to carry out controls. The hope that this pest would be jointly controlled by spraying operations against codling moth, was not fulfilled. Infestation by apple fruit moth larvae was only slightly reduced, and the impression was gained that applications were carried out too late to have any real effect on this pest.



Fig. 1

* Part publication of a thesis entitled "Contributions to the biology, ecology and control of *Argyresthia conjugella* Zell. on apples and mountain ash in Hesse".

** The studies were partly carried out with the assistance of the German Research Association. Facilities of the Crop Protection Office, Frankfurt (Main) were made available to the author for these studies. Both organizations are thanked for their kind cooperation.



Fig. 2

It is without doubt generally impossible for the orchardist to make a direct observation of apple fruit moth occurrence (Fig. 2), and in view of this an attempt was made to discover phenological data which would enable the control to be timed with adequate accuracy. As a rule, occurrence of *A. conjugella* is closely linked with the development of the fruits of mountain ash trees so that the obvious course was to establish the actual relationship between the development stages of this main host plant and the different stages of the moth. According to Ahlberg (1927), the moth starts to lay its eggs about 17 days after emergence of the imagines. The eggs are laid on the developing rowan fruitlets, and sometimes between the wilting floral leaves. In preliminary tests it had been established that the moth has a relatively short life-cycle, and this fact coupled with the observation that mountain ash is in bloom for 10 to 14 days led us to expect that the imagines ought to emerge at about the time when their host plant is in full bloom. The next step was to check the correctness of this assumption.

1. Phenological observations

a) Material and methods

For the phenological observations of *Sorbus aucuparia* L., a number of places were chosen in areas of varying climatic conditions in Hesse. Most of this work was done by the author himself, and information was also accumulated by extension workers of the Crop Protection Office, Frankfurt (Main). For comparison, data were provided by the German Meteorological Office (Agricultural-met. division). Parallel to these observations, cage tests were conducted to record the start and progress of emergence of the apple fruit moth. Improvised emergence vessels were used, which essentially consisted of 2 flower pots fitted together at their openings (Figs. 3 and 4). The lower pot

(S 1) was filled with humous forest soil, and served as the pupation chamber for the larvae; the upper pot (S 2) was not placed on the lower one until spring, before the start of the emergence period, its purpose being to guide the moths into the mounted trap glass (G). Until then, the lower pot, buried at the observation site, was simply covered with a piece of narrow-meshed wire netting.

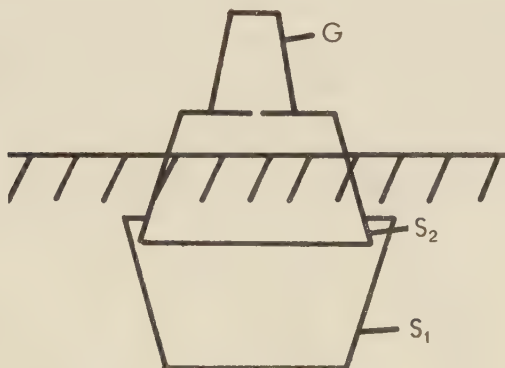


Fig. 3: Schematic diagram of cage used to observe emergence of *A. conjugella*. S₁ and S₂: flower pots forming lower and upper section of pupation chamber. G: trap glass



Fig. 4: Two emergence cages at observation site

Fully-grown larvae which shortly beforehand had migrated from rowan fruits, were placed in all the emergence cages. These larvae were caught as follows. In a field cage measuring 4 square metres, ripe rowan fruits were placed on wire mesh in such a way that the migrating larvae were able to lower themselves by their webs to the ground where they were collected for transfer to the observation cages. Afterwards this large field cage was cleaned, filled with fresh forest soil, and about 800 larvae were placed in it also for observation.

Larvae of one origin (Fuchskauten, Westerwald, 650 metres a. s. l.) were used for all the emergence tests.

All the emergence vessels were filled with larvae at Frankfurt. The prepared pots, however, were distributed at the observation sites during the autumn, as already mentioned.

In order to ensure that the conditions in the clay pots satisfied the requirements of the larvae for their pupation, a number of excess vessels were set out, which were checked already in autumn for the progress of pupation. The equipment used for the actual tests was purposely left undisturbed. A pupation

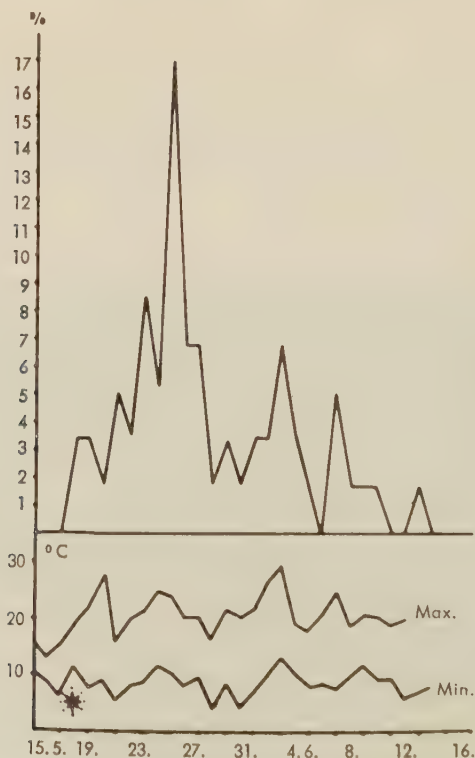


Fig. 5: Emergence curve for *A. conjugella* in relation to extreme temperatures and mountain ash blossom; observations at Oberstedten/Taunus in 1958

rate of 98 % was recorded in the check pots after 3 to 4 weeks. Comparison observations at the natural pupation situations of the moth under mountain ash trees, showed that spinning of the cocoon and pupation proceeded similarly in both cases.

The emergence vessels were checked after April 15 each year. To facilitate the daily counts of freshly emerged moths, the vessels were now covered with the second pot and the trap glass. The moths, attracted by the light, and also parasites present, gathered in the trap glasses. Observations and trapping were facilitated in a corresponding manner also in the large cage by partial darkening.

Emergence observation cages were placed, as already mentioned above, at situations where an observation of phenological data was possible. Registration of extreme air temperature values also appeared necessary to us in order to clarify the respective questions. In cases where temperatures could not be measured by the observers themselves in the immediate vicinity of the emergence cages, corresponding values were registered at local meteorological stations in the neighbourhood.

In Frankfurt (Main), the start of emergence in several clay pots was compared with that in the large stationary cage. It was only in 2 out of 5 clay pots that emergence began 1 day later than in the large cage, whereas in the others it started on the same day. In Fig. 5, the results of the emergence observations at Oberstedten, Taunus (1958) are plotted in relation to the daily temperatures and mountain ash blossom. The other results are given in Table 1.

Table 1: Full bloom of mountain ash (I) and start of apple fruit moth emergence (II) at observation situations and at varying heights in 1957 and 1958.

Year	Observation situation	Height a. s. l.	I	II	Difference
1958	Frankfurt (Main)	100	9. 5.	14. 5.	+ 5
	Friedberg	160	4. 5.	28. 4.	— 6
	Herborn	210	13. 5.	16. 5.	+ 3
1958	Frankfurt (Main)	100	16. 5.	15. 5.	— 1
	Friedberg	160	19. 5.	18. 5.	— 1
	Gelnhausen	160	21. 5.	17. 5.	— 4
	Schlüchtern	205	26. 5.	20. 5.	— 6
	Herborn	210	22. 5.	21. 5.	— 1
	Oberstedten/Ts.	230	18. 5.	17. 5.	— 1
	Hunoldstal/Ts.	380	28. 5.	2. 6.	+ 5
	Bottenhorn				
	Krs. Biedenkopf	500	1. 6.	10. 6.	+ 9
	Fuchskauten				
	(Westerwald)	650	5. 6.	2. 6.	— 3

b) Discussion of results

The results in Table 1 clearly show that there is a definite parallel relationship between the development of the apple fruit moth and that of its host plant, irrespective of the height of the observation situation above sea level. In 6 out of 12 cases, there was a difference of only 3 days or less between the full bloom of mountain ash and the start of apple fruit moth emergence. The maximum difference registered was 9 days (at Bottenhorn). In view of the fact that the full bloom can hardly be determined exactly to the day, in other words a subjective factor in the evaluations of the individual observers cannot be completely eliminated, this agreement concerning the 2 events can be regarded as adequate, all the more so since the trial controls have shown that a more accurate timing of the control is not necessary.

It was also established that the emergence of the moth reaches its peak 1 to 2 weeks after full bloom of the host plant, and is practically completed after a further 2 weeks.

Ahlberg (1927) had already discovered that the first imagines emerge when the minimum temperature rises above 6°C. This empirical value was confirmed by our studies. It was also established that on the day when emergence started, the maximum temperature was also in the region of 15°C in all cases.

The cage tests were supplemented by field observations under natural conditions. In the vicinity of mountain ash trees whose fruits had been severely infested the previous year, only isolated imagines were observed before the blossom. It was not until after the full bloom was over that large numbers of moths were observed on the trunks and lower branches of the mountain ash trees and on herbaceous plants growing under the overhanging parts of the crown.

Shallow wire cages were placed on the ground under mountain ash trees at 2 places before the start of the emergence period. Imagines were found in them also while the trees were in full bloom.

More emergence checks were carried out in 1959 at Friedberg (160 metres a. s. l.), Herborn (210 metres a. s. l.) and Bottenhorn (485 metres a. s. l.). Observations made here confirmed the results obtained in the previous year.

2. Control

On the basis of the information provided by the phenological observations, it was now possible to attempt to establish the correct time for carrying out a control of *A. conjugella* on apples, once again making use of the data published by Ahlberg (1927). The aim of the control had to be to eradicate as large a number as possible of the embryos; the best results were to be expected when the control was carried out immediately before the newly hatched larvae started to tunnel into the fruit. The peculiarity of the young larvae of *A. conjugella* to tunnel directly beneath the apple peel for some time after entering the fruit also led us to expect that the applied product would continue to be effective against these larvae for a few days after they entered the fruit.

According to Ahlberg, the moths start to lay their eggs about 17 days after emerging. The eggs then take a further 13 days to develop to that it can be expected that the caterpillars will enter the fruits 4 to 5 weeks after the moths emerge.

a) Trial controls on apples

An exploratory trial control was already carried out in 1956 in an orchard near Herborn (290 metres a. s. l.). The test (Ontario variety) included an untreated plot of 12 standards and a treated plot of 23 standards. The first treatment was on July 12, 1956, in which a lindane-dichlorodiphenyltrichloroethane product was applied at 0.3 % by means of a motor sprayer. In the second treatment on July 27, 1956, the same product was applied at 1.5 % by means of an atomizer. The result — 16 % infestation in the untreated plot, 1 % infestation in the treated plot — was surprisingly good when it is considered that the first spraying date was fixed at random. In actual fact, this control date was rather late when compared with the observations on moth emergence carried out at the same place in 1957 and 1958. The fact that the spring weather came unusually late in 1956 so that the moths emerged later than in other years, undoubtedly contributed considerably to the good result that was obtained. Nevertheless, this test proved the effectiveness of the product.

In a test carried out in 1957 near Rüchenbach (300 metres a. s. l.), the first attempt was made to time the control according to the start of apple fruit moth emergence. The moths began to emerge on May 13. The sprays were carried out on June 25 and July 8, in other words 43 and 56 days, respectively, after the start of moth emergence. As the results discussed below show, this control was timed much too late.

The test was carried out with 3 replications. The products were applied by means of an atomizer and the concentration was correspondingly raised. Details of the products applied and the results of the control are given in the following table.

Table 2: Control of apple fruit moth, at Rüchenbach in 1957

Treatment	% fruit infestation
1. Check (untreated)	17 %
2. Lindane + dichlorodiphenyltrichloroethane (0.2 %) 2 ×	7.5 %
3. E 605 forte, 0.035 %, 1st treatment	
Lindane + DDT 0.2 %, 2nd treatment	4 %

In 1958, the controls were timed according to the start of moth emergence on the basis of Ahlberg's data for moth development:

1st treatment 30 to 35 days after start of moth emergence.

2nd treatment 14 to 16 days later.

E 605 forte was considered to be especially suitable for suppressing caterpillar infestation, firstly because of its translaminar action and secondly because it leaves no residues in the harvest crop. A combined preparation of lindane + dichlorodiphenyltrichloroethane was again used as the comparison product.

Emergence of apple fruit moth started on May 22. Spraying was carried out on June 24 and on July 10, in other words 33 and 49 days, respectively, after emergence began.

The test was carried out with 3 replications, and included 3 apple varieties: 4 to 6 standards of each variety were treated.

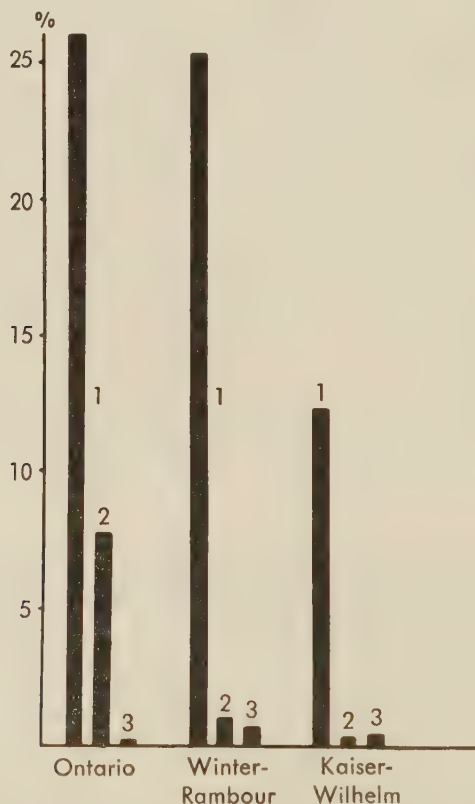


Fig. 6: Result of a trial control of apple fruit moth at Rüchenbach, 1958
Ordinate: % infested apples

The result of the evaluation of the crop is plotted in Fig. 6. The plots treated with E 605 forte (3) were practically free of infestation for all 3 apple varieties. Treatment with lindane + dichlorodiphenyltrichloroethane produced an equally good result on the "Winter-Rambour" and "Kaiser Wilhelm" varieties, although application of this product did not give a satisfactory effect on the "Ontario" variety (2). The reasons for this are not known. A striking feature is that "Ontario" is the most susceptible of these varieties. The overall result shows that the sprays were correctly timed.

In this test, fallen fruit was also evaluated seven times in the period from July 26 to September 30, 1958; codling moth infestation was also recorded, just as in the evaluation of the harvest crop (see Table 3). These counts provided a very interesting indication as to the success of the control. On the average, apple fruit moth infestation was greatest in the untreated plot (24 %), followed by the lindane + dichlorodiphenyltrichloroethane plot (14.4 %) and the E 605 forte plot (3.3 %). The comparative figures for codling moth infestation on fallen fruit were 13.6, 6.2 and 2.5 %, respectively.

Table 3:

	Evaluation of fallen fruit July 26.—Sept. 30. 1958		Evaluation of harvest crop on Oct. 3. 1958	
	Codling moth	Apple fruit moth	Codling moth	Apple fruit moth
Untreated	13.6 %	24.0 %	4.8 %	21.2 %
Lindane + dichloro- diphenyltrichloroethane	6.2 %	14.4 %	0.7 %	3.0 %
E 605 forte	2.5 %	3.3 %	0.0 %	0.4 %

Codling moth infestation of the harvest crop in the untreated plot was only about 5 %, whereas the average apple fruit moth infestation was recorded at 21 %. There was hardly any codling moth infestation at all in the treated plots. It appears as if fruits attacked by codling moth fall earlier than those infested by apple fruit moth. In contrast to the relatively high percentage of codling moth infestation on fallen fruit, there is only a very slight percentage on the harvest crop, whereas the percentage of apple fruit moth infestation on the harvest crop in the untreated plot is almost as high as that on fallen fruit.

Discussion of results

The combined results of the harvest crop evaluation show that the spray applications are most effective. E 605 forte almost completely prevented infestation by apple fruit moth larvae. The peculiarity of the young larvae of *A. conjugella* to tunnel very close to the apple peel before they enter the inside of the fruit, justifies preference being given to a product with a penetrating action.

For the control of *A. conjugella* on apples, the following recommendations can, therefore, be given based on the author's own studies and tests and on the data of Ahlberg (1927):

When observations on emergences are carried out, the first treatment should be made 28 to 35 days after the moths start to emerge.

The first control should also be timed according to the dates of mountain ash bloom. Studies conducted over several years allow the

conclusion to be drawn that the apple fruit moth starts to emerge at the latest when mountain ash is in full bloom. The first spray should be applied 21 to 28 days after full bloom of mountain ash, followed by another 1 or 2 applications at intervals of 10 to 14 days.

In areas where there is a regular occurrence of apple fruit moth, preference should naturally be given to the practice of direct observation of the moth flight.

For determining the date of moth emergence, suitable equipment is provided in the form of the pots described earlier, or simple-type bottomless wooden boxes measuring 0.4 sq. m. to 0.5 sq. m. in area and approximately 25 mm deep, with a hinged lid. The lid must be made of fine wire-mesh or plastic netting. The boxes should be filled with ripening, red mountain ash berries, and placed in the soil at a depth of about 5 to 10 centimetres in half-shade under a tree, in late summer from the end of July onwards. The larvae that crawl out of the fruit after a time, will pupate in or on the soil in the box. The fruits must be removed from the boxes about 3 to 4 weeks after being put into them, in order to prevent formation of rot.

In late spring, from about May 15 onwards, emergence of the first moths can be observed by checking the boxes daily.

The recommended practices for correct local timing of controls attach increasing importance here in view of the fact that the areas of apple fruit moth infestation are primarily in highland regions where conditions often greatly vary within a small area. Central supervision of control operations thus meets with very great difficulties in these areas from the very outset.

b) Trial controls on mountain ash

Possibilities of course also exist for controlling *A. conjugella* on mountain ash itself, at least in places where the moth has not completely migrated to apples.

Treatment of the trees, e. g. on road verges and at the edges of woods near to apple orchards, with a suitable insecticide would definitely bring about a decimation of the moth population. Such factors as the often unfavourable position of the trees, water cartage and the question of equipment make it difficult, however, to carry out such treatments.

In our opinion the apple fruit moth could be eradicated at far less expense and, above all, much more effectively if the controls were to be directed against the caterpillars as they are about to enter the chrysalis stage. The fully grown larva usually drops to the ground directly below the tree crown, where it seeks a suitable place to spin its cocoon and pupate. Insecticidal treatment of the soil over an area extending somewhat beyond that covered by the tree crown would bring the wandering larvae into contact with the poison. The time when the larvae spin their way down to the ground depends upon the height of the place above sea level; at all events, the larvae do not start migrating to the ground until the mountain ash berries begin to redden. It would suffice to start treatment of the ground, using a simple-type hand duster, from this stage onwards. The treatments would have to be repeated at intervals of 4 to 6 days, according to the weather.

Controls carried out along these lines for 2 or 3 consecutive years ought to completely eradicate the population of *A. conjugella* on its natural host plant.

The small-scale test described below confirms the correctness of this train of thought.

Shallow boxes filled to a depth of about 4 centimetres with moist forest soil, were placed flat in the ground, and the surface was sprinkled with a thin layer of insecticidal dust. Afterwards, 50 larvae, about to enter the chrysalis stage, were placed in each box (1 replication); the boxes were then covered with fine gauze. The test was started on August 31, 1957. The evaluation on September 7, 1957 gave the following results:

Table 4:

	In larval stage		Dead		In cocoon	
	1	2	1	2	1	2
Untreated	0	0	1	0	49	50
Lindane + dichlorodiphenyl-trichloroethane dust	0	0	47	43	3	7
E 605 dust	0	0	50	50	0	0

An interim check 2 days after the larvae were placed in the boxes, showed that all the larvae were already dead in the E 605 boxes. Approximately 25 % of the larvae in the dichlorodiphenyltrichloroethane + lindane boxes were severely harmed.

The results of the final evaluation showed that none of the larvae in the E 605 boxes made a cocoon, whereas an average of 10 % were able to do so in the dichlorodiphenyltrichloroethane + lindane boxes. In the untreated boxes, all the larvae placed in them made cocoons in the soil.

These results cannot be readily applied to field conditions but they do indicate that when the ground under the tree crown, in fact over an area extending beyond that covered by the crown, is thoroughly treated with insecticidal dust, the great majority of the migrated larvae will not be able to pupate.

This method would enable the migratory flight of *A. conjugella* from fairly accessible mountain ash trees to neighbouring orchards, to be reduced to a minimum.

Fruit-bearing mountain ash trees must on no account be removed without at the same time taking steps to eradicate the moth population, otherwise the new moth generation would only migrate in far greater numbers to apple trees in spring for want of somewhere to lay their eggs.

Existing mountain ash trees can, on the other hand, be well used as "trap trees" when the fully-grown larvae are controlled in the described manner. Removal and destruction of the berry clusters before the insects migrate, would be a time-wasting operation.

Summary

Regular occurrence of *A. conjugella* on apples in certain parts of Hesse makes it necessary to carry out controls of this pest.

Phenological observations of *Sorbus aucuparia* and checks on *A. conjugella* emergence showed that the emergence of the adult moths approximately coincides with the full bloom of mountain ash, irrespective of the height of the situation above sea level. This fact was utilized in combination with the results of observations on moth flight in emergence cages and in the field, for the purpose of timing controls. E 605 forte effectively protects apples against infestation by apple fruit moth larvae. If observations of moth emergence are carried out, the first spray should be applied 4 to 5 weeks after the moths start to emerge, or, alternatively, 3 to 4 weeks after the full bloom of mountain ash.

References

1. Ahlberg, O. (1927):
Rönnbärsmalen, *Argyresthia conjugella* Zell., Meddelande Nr. 324 from Zentralanstalten för försöksväsend, Stockholm.